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THE EVOLUTION AND DEVELOPMENT OF SURGICAL INSTRUMENTS

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GENERAL OBSERVATIONS

IN attempting to trace the origin of the more important instruments employed in surgery, we are led back to the palæolithic period, when the stone knife, flaked-flint, and obsidian were the sole implements used for cutting or scraping, as instanced in the evidence of trepanning by primitive man from skulls of prehistoric times. Their use in other surgical operations, although suggested by instruments still employed by aboriginal tribes, must, however, be largely conjectural. We know that certain instruments were undoubtedly evolved from the tools used by the early craftsmen, such as the drill, the saw, and the wimble, but the cutting-knife or scalpel must have been employed in far earlier times and was probably the earliest instrument used by the surgeon.

Our chief sources of information respecting the shape and form of the instruments used in surgery in ancient times are the descriptions given by classical authors and representations in marble and stone, for it is not until the Roman period at the beginning of the Christian era that we have any actual specimens of the instruments employed by the surgeon.

In the Hippocratic writings, stress is laid on the importance of the instrument being adapted to the hand of the operator and the means he should use in order to acquire " dexterity and elegant manipulation ".

Thus we are told, " The nails should be neither longer nor shorter than the points of the fingers and the surgeon should practise with the extremities of the fingers; the index finger being usually turned to the thumb; when using the entire hand it should be prone, and when both hands, they should be opposed to one another.

" It frequently promotes a dexterous use of the fingers when the space between them is large and when the thumb is opposed to the index. One should practise all sorts of work with either of them and with both together (for they use both alike) endeavouring to do them well, elegantly, quickly, without trouble, and promptly." Thus says the Greek writer.

Heister, writing in the eighteenth century, remarks that " a surgeon's hand would be of little service to him if he was not supplied with a variety of

instruments", and so in the course of time instruments of every shape and form have multiplied. Every surgeon knows when an instrument is best adapted to his hand, and thus we have come to the innumerable differences in the shape and form of blades and handles that have been devised by operators throughout the centuries.

I. THE SCALPEL

The Greek word used by Galen and Aëtius to denote the instrument we now call the scalpel is σμίλη and by the Latin authors *scalpellus*. It is described as a small light knife used in operations. The earliest known representation of the instrument is on a sculptured ex-voto tablet of stone that was found on the site of the temple of Æsculapius on the Acropolis at Athens, and probably dates from about 300 B.C.—*Fig.* 1 (2). It depicts a case of scalpels arranged blade and handle alter-

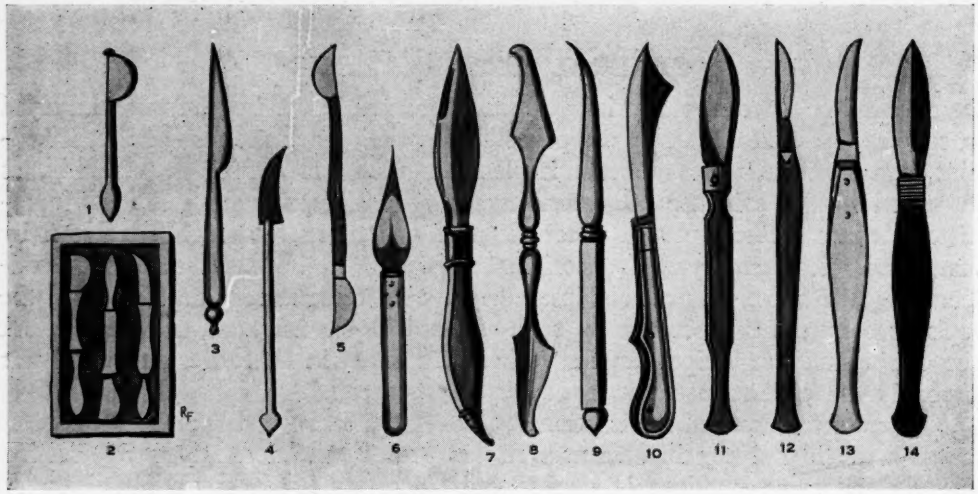

FIG. 1.—Scalpels from 300 B.C. to the 19th century A.D. For details, *see* text.

nately. The curved blade of the third shown is similar in shape to some in use at the present day. The other two are what are alluded to by Hippocrates as the "bellied scalpel", used "to incise the outer integument between the ribs". Galen calls it the "bellied surgical knife", so termed from the Greek word meaning "like the breast of a woman". That scalpels with blades of this shape were introduced by the Greco-Roman surgeons into Egypt about 150 B.C. is evidenced by an incised stone tablet in the temple of Asklepios at Kôm-ombos on the Nile (1). On this interesting tablet we have also many representations of the instruments used in gynæcology by Greco-Roman surgeons in the second century before the Christian era.

It is probable that these instruments were made of steel, for long before the date of the earliest medical writings Greece had passed into the iron age, and by the time Hippocrates flourished the metal was in common use. The Greeks knew the process of tempering steel, and, there is little doubt, employed it for making their cutting instruments, such as the blades of knives made for surgical use.

Galen remarks, in his time, " the best quality of steel yielded a knife which neither blunted easily nor bent or chipped ".

It is notable that some instruments like the scalpel were made with double ends with the handle in the centre, and so shaped to give a grip for the fingers, for, as Hippocrates observed, " All instruments ought to be well suited for the purpose in hand as regards their size, weight, and delicacy ".

After the Hippocratic period there is a gap of centuries until we come to the Roman era. Here we are on surer ground, as fortunately owing to the material of which they made their surgical instruments we have many actual specimens still in existence. The Roman surgical instruments which have been discovered are mostly of bronze, and although iron and steel were also employed for blades, they have perished in the course of time, but the bronze has remained.

The ordinary scalpel used by Roman surgeons usually had a straight sharp-pointed blade with sometimes a curved cutting-edge (3). The illustration represents one found among the surgical instruments discovered at Pompeii. Others were made with double ends, having a blade at one end and a leaf-shaped spatula at the other which could be used as a blunt dissector. The centre bar or handle was of bronze and was either round, square, or hexagonal in form. In the single scalpels and knives, the steel blade was fixed in the handle by a binding-thread or wire, and was detachable so as to allow it to be removed for cleaning. The blades were generally straight or curved, with sharp points, and sometimes had double cutting-edges.

From the specimens we have of Roman instruments it appears that, whenever possible, it was usual to combine two instruments in one. Thus we find many of the probes have a spatula at one end and a scoop or spoon at the other. The vulsellæ sometimes have a scoop, probe, or raspatory at the opposite ends, giving the Roman surgeon two instruments in one. This custom of combination was carried on by instrument-makers until comparatively modern times.

The handles of some of the Roman instruments are often finely worked and occasionally damascened with silver; others show traces of having been gilded. Certain specimens which exhibit clever craftsmanship have a figure of a deity or the head of an animal as a terminal, and are real works of art.

It is notable that most of the Roman instruments were made entirely of metal and so could be easily cleaned by boiling in water, also that the blade and handle were at times connected by something like our aseptic joint.

Aulus Cornelius Celsus (25 B.C.–A.D. 50), in his important work on medicine, refers to the use of the scalpel for " dilating a wound to facilitate the removal of a weapon embedded in the flesh ",* and directs the operator to " make the incision sufficiently large so the weapon may be extracted ".† He also recommends the employment of a scalpel when extracting a foreign body, such as a stone that has become embedded, so as to enable it to be extracted with a forceps. He tells us later, that " Heraclides the Tarentine advises in an operation on the eye, following adhesion of the lids to the white of the eye, to effect a separation with the sharp edge of the scalpel, cutting very gently ".

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* Book VII, Cap. 5, Sec. 2.
† Book VII, Cap. 5, Sec. 6.

Isidore of Seville (A.D. 560–630) mentions several surgical instruments used in his time, but it is not until we come to the tenth century in the days of Albucasis or *Abu'l Kasim ben Abbas al-Zahrawi*, the Arabian surgeon, that we have fuller descriptions and figures of the instruments employed. There are a number of manuscripts of his work extant in Arabic, Persian, and Latin, the latter having been translated by Gerard of Cremona (A.D. 1114–1187). The drawings of the instruments illustrating the codices vary according to the style and period of the delineator, but probably the best in this country is the manuscript now in the Bodleian Library, dated A.D. 1271.* The drawings are made in black ink in realistic style, so we are able to judge of their detail. The scalpel depicted (4), reproduced from this MS., shows an instrument of metal with a small curved blade and a single inner cutting edge. The straight handle terminates with a leaf-shaped spatula. There is another manuscript of the work in the Bodleian of a later date† in which the drawings are outlined in red ink, but the MS. with the most ornate illustrations in colour is that preserved in the British Museum, which will well repay study.‡

Handles of wood and bone appear to have been introduced about the fourteenth century, and an example is depicted in the manuscript, believed to date from 1350, that belonged to John Wryghtson, now in the library of St. John's College, Oxford.§ It contains fifty-four drawings of instruments used at the period, including a double-ended scalpel (5). The blades at either end are similar in shape, are curved on the cutting-edge, and have straight backs. They are secured to the flat handle (apparently of wood) by metal collars, and were probably removable.

In the sixteenth century the blades of scalpels became more leaf-shaped and had double-cutting edges. They were secured to the round handle of wood or bone by rivets, as shown in the drawing from Della Croce's *Cirurgia*, printed in 1598 (6). In the same year, Guillemeau figures a scalpel with a similar type of blade, but narrower and slightly bevelled off near the point. It has an elaborate handle, slightly shaped to fit the hand, and has a decorated collar. The handle of wood is hexagonal in shape and is terminated with a sharp metal cap (7).

In the seventeenth century we have examples of the 'all metal' instrument, as shown in the scalpel depicted by Garengeot (8). This, again, is a double-ended instrument of metal with curved blades turned at the ends. About the same period, Fabricius of Aquapendente figures a long-bladed scalpel with an inside cutting-edge, sharp pointed and slightly curved at the apex. It has a square-shaped handle as long as the blade, terminating with an acorn-shaped knob (9).

A scalpel with a curiously shaped blade and handle is depicted by Heister in 1740. The scimitar-like blade has a single cutting-edge and has evidently a broad, flat back. The handle of bone is shaped to the hand to give a firm grip, and is rounded off at the end (10). Perret, in 1772, figures a scalpel with a leaf-shaped blade and straight single cutting-edge. It is riveted to a shaped bone handle, and is the first shown with a flattened terminal (11).

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* Marsh 54, Bodleian Library.
† Huntington 156, Bodleian Library.
‡ Add. 36617 MSS. British Museum.
§ Photostats of these drawings are in the instrument room at the Royal College of Surgeons.

Towards the end of the century came handles of ivory or of chequered wood, with the object of giving a firmer grip and to prevent slipping. The blades were leaf-shaped with double cutting-edges and secured to the handles with a metal collar. The flat handles curved out and again inwards, and terminated in a spatula end (14).

The surgeons of the nineteenth century appear to have preferred much shorter blades, either straight or slightly curved. The thin, flat ivory handle came into vogue, as shown in the favourite scalpel used by Sir William Fergusson, now among the collection of instruments in the Museum at the Royal College of Surgeons (12). A scalpel of a similar type, with a short, slightly curved blade and ivory handle, was used by Sir William Flower in 1861 (13). It was not until the last half of the nineteenth century, after Lister's time, that a new era began in the materials used in the manufacture of all surgical instruments. For the purpose of sterilization, instruments made entirely of metal were once more necessary. Handles of ivory, bone, wood, and tortoiseshell had to be discarded, and may now be regarded only as relics of a bygone age.

AN UNUSUAL CASE OF HYPERPARATHYROIDISM
ANTERIOR MEDIASTINAL PARATHYROID TUMOUR REMOVED BY TRANS-STERNAL APPROACH

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The literature relating to hyperparathyroidism increases every year, and our knowledge regarding the pathology and the clinical aspects of this disease is augmented almost monthly by the record of cases culled from nearly every country and clime.

This paper does not purport to re-echo the now well-known characters of the condition, but merely desires to remind surgeons of the possible existence of a parathyroid tumour in the anterior mediastinum, when careful surgical exploration has yielded negative findings in the neck and the other less abnormal sites; it is hoped that the publication of this case may encourage and stimulate others to attack the thorax when the diagnosis of hyperparathyroidism rests on sure clinical, radiological, and biochemical foundations and when careful search has failed to demonstrate the pathogenic tumour.

An attempt has also been made to indicate the importance of embryology in explaining aberrant positions of parathyroid tumours, and those parathyroid tumours have been collected which operation has demonstrated to be situated within the chest.

CASE REPORT

Maud T., married, 44 years of age.

History.—During 1931 the patient's attention was drawn to a swelling on the left side of the lower jaw by the dental surgeon whom she had consulted in respect of the extraction of some teeth. After preliminary radiography a piece of the mandibular tumour was removed for microscopic examination and reported as a "myeloid epulis". In April, 1932, she was admitted into one of the London teaching hospitals and the tumour was excised; but in June of the same year, during the latter months of her pregnancy, a recurrent swelling was observed in the mandible and also one in the right tibia; the patient was advised to submit herself to another operation when her child had been born. On re-entry into hospital after parturition the patient was informed that the condition of her heart (!) precluded any further operative interference, and she was transferred to a County Council Institution with the diagnosis of "multiple malignant tumours of bone".

Early in 1934 she fell downstairs and suffered a greenstick fracture of the right humerus, and in April, 1934, she sustained a spontaneous fracture of the surgical neck of the same bone. Accidental circumstances brought the patient under the notice of our friend Dr. Michael Kremer, who, impressed by the appearance of the radiograms and by the length of the clinical history, at once considered the possibility of hyperparathyroidism. Chemical investigation of the blood demonstrated the blood-calcium to be considerably above normal, and a piece of rib which had been removed and submitted to microscopic examination showed decalcification with considerable osteoclastic activity. Dr. Kremer's opinion on the microscopic appearances of the portion of bone removed was confirmed by various workers in the Bland-Sutton Institute of the Middlesex Hospital. The patient was admitted to Middlesex Hospital in June, 1934, for further investigation; control-radiographs were made and a calcium balance was performed, thereby confirming the diagnosis of hyperparathyroidism.

On Examination.—The patient's weight on admission was 6 st. 7 lb., and she complained of pain in the right arm and left thigh.

Radiography.—Radiography demonstrated a generalized osteoporosis of all the bones, when comparison was instituted with those of a control subject. The right humerus exhibited

an incompletely united fracture; there was a cyst in the lower end of the right femur, while the left femur contained a small cyst in the middle of the shaft and another at the upper end. In the right tibia was a cyst at the upper end and a smaller cyst in the middle of the shaft. The vertebral column showed scoliosis, and X-ray investigation revealed compression of the bodies of the ninth, tenth, and eleventh dorsal vertebræ. The pelvis exhibited areas of rarefaction, and the same appearances were discernible in the occipital bone.

Urinalysis.—

Non-protein nitrogen	32·0 mg. per 100 c.c.
Urea	32·0 „ „ „ „
Calcium	14·8 „ „ „ „
Phosphates	2·8 „ „ „ „
Total protein	0·015 g. „ „ „
Bence-Jones protein	Negative

Calcium Balance.—On a three-day intake of 0·3 g. of calcium the total calcium eliminated in the urine and fæces amounted to 1·26 g. Similar investigations were repeated on two subsequent occasions, and on the same intake of 0·3 g. of calcium, 1·33 g. and 0·85 g. were excreted in urine and fæces.

A diagnosis of hyperparathyroidism was made with confidence, and the patient was transferred to our care for operative treatment.

OPERATION (G. G-T.), Aug. 20, 1934.—Under general anæsthesia a collar incision was made, the infrahyoid muscles being divided. The posterior border of each lobe of the thyroid was carefully inspected and two normal parathyroids on the right side were identified. Some suggestive material was removed from the left lobe, but the hope that this might prove to be of parathyroid structure was dispelled by the microscopic investigation.

FIG. 2.—Parathyroid tumour removed from anterior mediastinum. (*Actual size.*)

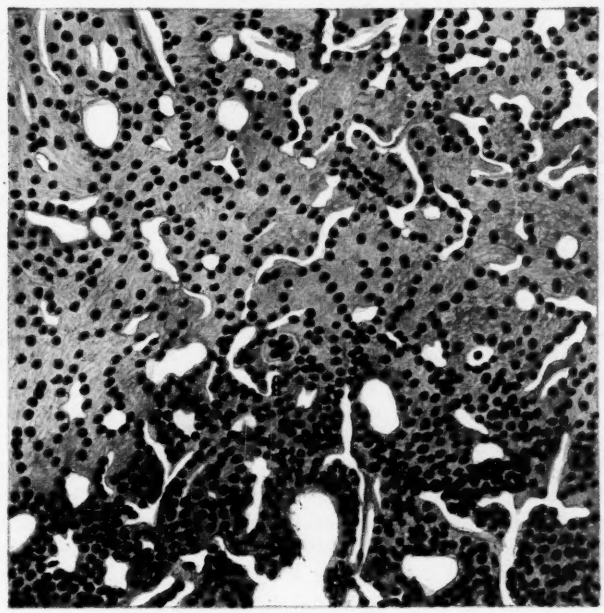

FIG. 3.—Microscopical section of anterior mediastinal parathyroid tumour.

Fortified by the wealth of information contained in Walton's[1] excellent paper we explored the mediastinum from the neck with thoroughness and diligence; the retro-œsophageal space was not neglected, and was digitally explored even well down into the superior mediastinum. After a lengthy but disappointing search the wound was reluctantly closed.

The diagnosis of hyperparathyroidism rested on such sure biochemical findings that further operative interference was deemed advisable, and on Sept. 3 the thorax was again explored surgically. Under general anæsthesia, a vertical incision was made in the middle

FIG. 4.—Radiograph of right humerus, June 9, 1934, exhibiting fracture of surgical neck.

FIG. 5.—Radiograph of right humerus, July 15, 1935, showing union of fracture and increased density of bone.

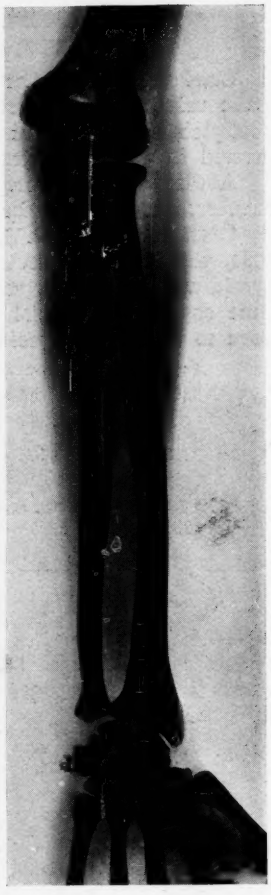

FIG. 6.—Radiograph of bones of right forearm, June 9, 1934.

line over the manubrium sterni and carried well down over the gladiolus below; above the knife was carried up to the previous collar incision. The manubrium sterni and upper part of the gladiolus were longitudinally split after the method of Sir Thomas Dunhill[2]; a transverse saw-cut was made just above the third costal cartilages, and on each side the incision was carried outwards through the intercostal muscles of the second space; the edges of the divided bone were retracted and the superior and anterior mediastinum exposed. A tumour was found in the anterior mediastinum behind the angle of Louis and upper part of the gladiolus; it rested against the left pleura. After removal an immediate frozen section

confirmed its parathyroid character. Some small vessels required ligature; the edges of the sternum were brought together and the wound was closed.

The post-operative convalescence was almost uneventful; two days after operation the patient complained of "pins and needles" all over; and on the fourth day a positive Chvostek had developed on the right side. A week after operation the Chvostek had become negative, and in another two days the patient had almost lost the tingling feeling. On Aug. 7, the blood-calcium had been 13·8 mg. per 100 c.c.; on Sept. 13 it amounted to only 8·8 mg. per 100 c.c.

FIG. 7.—Radiograph of bones of right forearm, July 15, 1935, showing increased density of bone.

FIG. 8.—Radiograph of right femur, June, 1934.

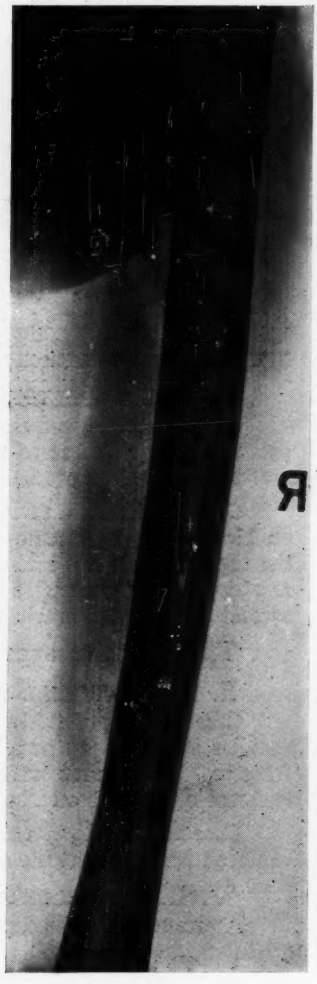

FIG. 9.—Radiograph of right femur, July, 1935, showing increased density of bone.

PATHOLOGICAL REPORT (Bland-Sutton Institute).—A soft ovoid tumour, $1\frac{1}{4} \times \frac{1}{2} \times \frac{1}{2}$ in. (*Fig.* 2). Weight 4 g. Microscopically the tumour closely resembles normal parathyroid tissue, with marked hyperplastic areas (*Fig.* 3).

SUBSEQUENT HISTORY.—The patient was seen again in the end of June, 1935, when her general health was good, but there was a complaint of loss of strength in her left leg. On radiography performed at this period the bones exhibited a greater density than before the operation undertaken nine months previously (*Figs.* 4–9), and several of the cysts appeared

smaller. The sudden onset of hæmaturia during the calcium-balance investigations prevented the completion of this research; the bleeding was found to come from the right ureter; the usual methods of urinary investigation failed to reveal any other abnormality than the presence of blood-cells in the urine from the right kidney. A favourable report was received from the patient in January, 1936, but for domestic reasons she found it inconvenient to re-enter the hospital for another calcium-balance estimation, nor was she even anxious to attend for renewed radiography of the bones!

OTHER REPORTED CASES OF INTRA-THORACIC PARATHYROID TUMOUR

Not many parathyroid tumours completely retro-sternal have been reported. Obviously a tumour at the inferior pole of the thyroid will extend under the sternum if the parathyroid neoplasm be of sufficient size. The following cases collected from the literature include only the completely mediastinal parathyroid tumours, and of these few only one or two have been removed by trans-sternal approach.

T. W. MIMPRISS and R. W. BUTLER'S[3] case.—

A male, aged 17 years, suffering from hyperparathyroidism was operated upon by W. H. C. Romanis and was found to have a tumour 12 mm. in length embedded in the anterior surface of the thymus in a retro-sternal position; the tumour and the surrounding thymic tissue were excised with the happiest results. Operative approach was from the neck.

SIR JAMES WALTON'S[1] two cases.—

Case 1.—A. F., a female aged 40 years, showed well-marked osteitis fibrosa. At operation a large rounded retro-sternal tumour, lying to the left side of the trachea and measuring 3 × 1 in., was removed. The patient made great improvement after operation.

Case 2.—B. Y., a female aged 51 years, with typical osteitis fibrosa, was operated upon on Nov. 26, 1930, but no tumour was found. At a second operation on Dec. 1, 1930, the thyroid fascia was incised and a small parathyroid tumour discovered and excised; the resulting cavity exposed a retro-œsophageal tumour the size of a plum, lying opposite the second and third thoracic vertebræ.

The operative approach in each of these two cases was from the neck.

E. D. CHURCHILL and O. COPE'S[4] two cases.—

Case 1.—Captain M., a male aged 35. The tumour from this case was a smooth nodular structure, 25 mm. in diameter, discovered at the seventh operation by *splitting the sternum*. The patient unfortunately died a month after the operation, following emergency removal of a renal calculus.

Case 2.—M. R., a female aged 36. The tumour, measuring 25 × 30 × 10 mm., was removed from behind the second costal cartilage, with excellent result.

W. L. WELBROOK'S[5] case.—

A woman of 36 years, with typical hyperparathyroid history. A tumour was found "situated in the carotid triangle, substernally in the right lobe at the inferior pole of the thyroid gland". This somewhat slipshod anatomical definition presumably means that the tumour was situated posterior to the sternum, behind which an enlarged thyroid pole also descended. It was large, measuring 50 × 35 × 30 mm., and loss of symptoms followed the excision.

F. E. MANDL'S[6] case.—

A female aged 47, presenting typical bony changes with many spontaneous fractures. A retro-sternal tumour measuring 40 × 35 × 2 mm. was removed. The patient died some weeks later after leaving hospital.

M. RENAUD et al.[7]—

A retro-sternal tumour, 45 × 25 mm. in size, was discovered at post-mortem in a woman who had most extensive bony changes.

HILDING BERGSTRAND'S[8] case.—

This author records a curious case in which at post-mortem a parathyroid tumour the size of a pigeon's egg was found in a retro-sternal fatty thymus in a woman of 64; the tumour was soft and had a smooth glossy surface. The bones showed typical changes of osteitis fibrosa. An adenoma of the adrenal was present as well as an adenoma of the thyroid, which latter appears to have given rise to metastatic deposits.

FRANK LAHEY[9] has on two occasions found and removed a parathyroid tumour after splitting the sternum.

THE BEARING OF EMBRYOLOGY ON THE POSITION OF THE PARATHYROID GLANDS

The varied position occupied by the parathyroid glands in the adult has been an increasing source of embarrassment to the surgeon ever since parathyroidectomy has been practised for diffuse osteitis fibrosa. A knowledge of the abnormal situations where parathyroids may be found is obviously of paramount interest to the operator, and the embryology of these structures is of importance in indicating those sites where an aberrant gland is likely to be found, and particularly in explaining the retro-sternal position in which such a tumour may make its appearance. The following account of the parathyroid migration is based largely on Weller's[10] instructive paper.

At a very early stage there appear in the pharynx lateral diverticula, the so-called pharyngeal or branchial pouches, of which only four can be recognized on each side in the human embryo. It is with the third and fourth pouches that the parathyroids are concerned: from the third arise the thymus and, at first sight paradoxically, the *inferior* parathyroid glands; while from the fourth come a part of the thyroid and the *superior* parathyroid glands (*Fig.* 10). The inferior parathyroid glands sometimes receive the synonym of the parathymic glands or parathyroids III, the number referring to the pouch of origin, and similarly the superior parathyroids may be designated by the synonym of parathyroids IV.

The epithelium of these pouches proliferates, and each pouch becomes first a tubular process open to the pharynx, then a vesicle connected to the pharynx by a thin elongated stalk, which latter ultimately disappears without trace. During the tubular stage, a group of cells differentiates itself from the dorso-lateral aspect of the pouches, and these cells subsequently form the respective parathyroid glands.

The third pouch grows forwards and downwards, and a study of the figures in the text (*Figs.* 10–13) demonstrates that the diverticulum passes lateral to the common carotid artery to which it had previously been posterior. At the same time the pouch loses its connection with the pharynx and may now be re-labelled the primitive thymus; it consists of a head, of which the inferior parathyroid forms a large part, a neck, and a body. The tissue of the head and neck atrophies, while the body continues its downward migration to become the retro-sternal thymus of post-fœtal life. The atrophy of the head and neck of the thymus leaves the inferior parathyroids stranded on the lateral side of the inferior pole of the thyroid; presumably their characteristic adult position on the postero-medial aspect of the lower pole is due to their being overlapped by growth of the thyroid. It is interesting in this connection to note that Millzner[11] has remarked the frequent occurrence of a parathyroid on the lateral thyroid capsule.

The fourth pouch is medial to as well as below the third, for the pouches overlap from above downward, like the imbricating tiles of a roof. The diverticulum grows forwards and not downwards; passing medial to the down-growing third

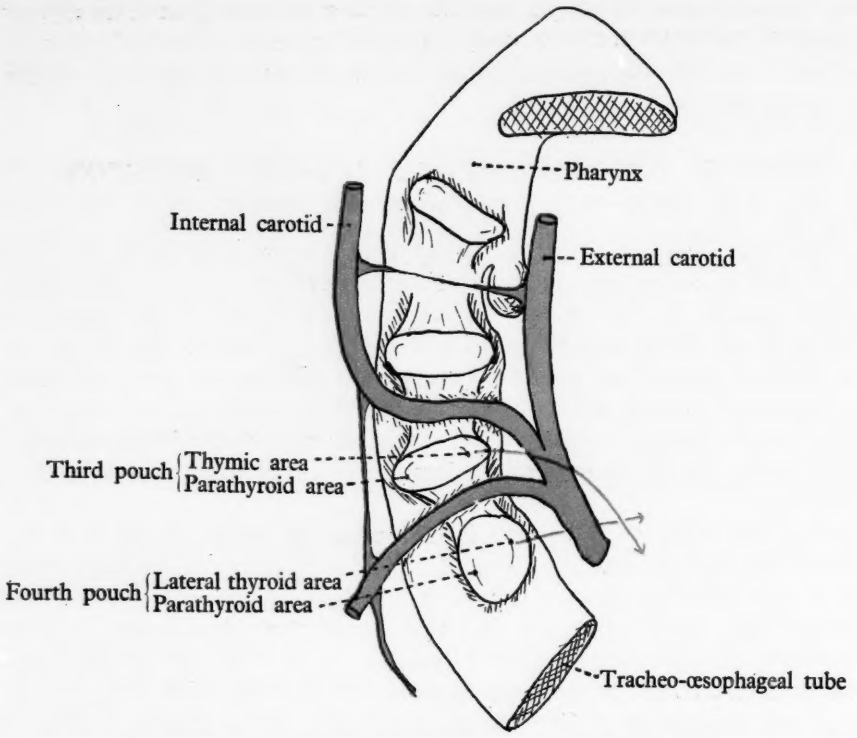

FIG. 10.—To illustrate relations of arteries to pouches. Seen from the right side. (*Modified from G. L. Weller.*) (Green arrows indicate direction of pouch migration.)

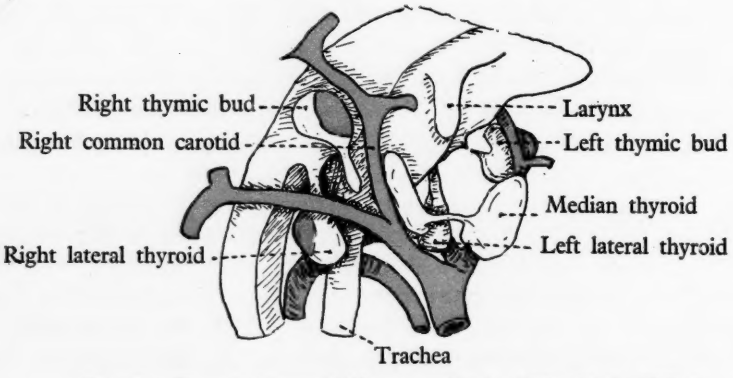

FIG. 11.—Human pharynx (14·5-mm. embryo). (*After G. L. Weller.*) (Parathyroids coloured green.)

pouch and the common carotid artery, it fuses with the median thyroid, which has meanwhile descended from the region of the foramen cæcum of the future tongue. The thyroid is thus composed of a median and two lateral pieces, and attached to the dorsal border of each lateral part is a group of cells destined to form the superior parathyroid body of either side.

It will be seen that the superior parathyroids have thus a shorter and less adventurous path than the inferior parathyroids, and this fact accounts for their relatively constant position behind the middle part of the thyroid. The position of the inferior parathyroids is regulated by the differential growth and atrophy of the thymus, and should the parathyroid cells appear in the third pouch in a position slightly varying from their normal dorso-lateral one, or should the neck of the thymus fail to atrophy at the appropriate moment, they are in danger of being drawn down within the thorax.

There appears to be no evidence that any parathyroid tissue arises from either the second or a rudimentary fifth pouch in man, nor is there, as is sometimes

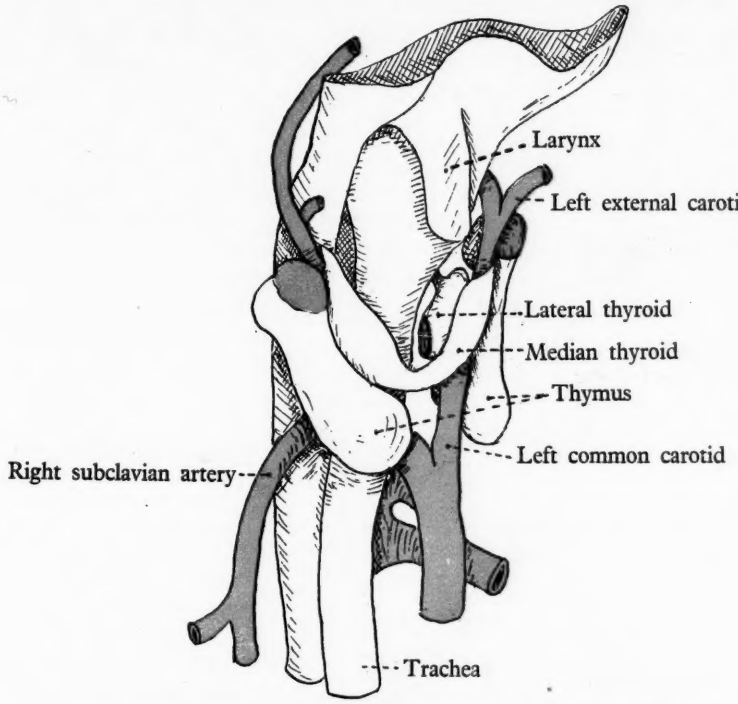

FIG. 12.—Human pharynx (16·8-mm. embryo). (*After G. L. Weller.*)
(Parathyroids coloured green.)

stated, a normal thymic component of the fourth pouch. In view of the latter fact the superior parathyroids owe their migration to the lateral thyroid component, also known to embryologists as the ultimo-branchial body. It is only fair to add that there is considerable controversy concerning the amount of the adult thyroid gland formed by the ultimo-branchial body, although all agree that it fuses with the median thyroid.

On embryological grounds, therefore, it is theoretically possible to find the superior parathyroids anywhere on a line joining the pyriform fossa of the pharynx to the middle of the posterior aspect of the thyroid gland, such a line passing medial to the carotid sheath. The inferior parathyroids may be anywhere on a line joining the side of the pharynx, immediately below the greater cornu of the hyoid bone, to the upper part of the pericardium. Such a line will pass from behind, lateral

to the internal and common carotid arteries, but *between the arteries and the internal jugular vein.* A study of *Figs.* 10–13 will make the relation of this line to the arteries clear. Its relation to the vein is not depicted, but the vein is formed from plexiform channels which lie dorso-lateral to the pharynx and its derivatives. This point has been kindly checked for us by Dr. J. Dixon Boyd on some 12- to 16-mm. embryos at the Cambridge Anatomy School.

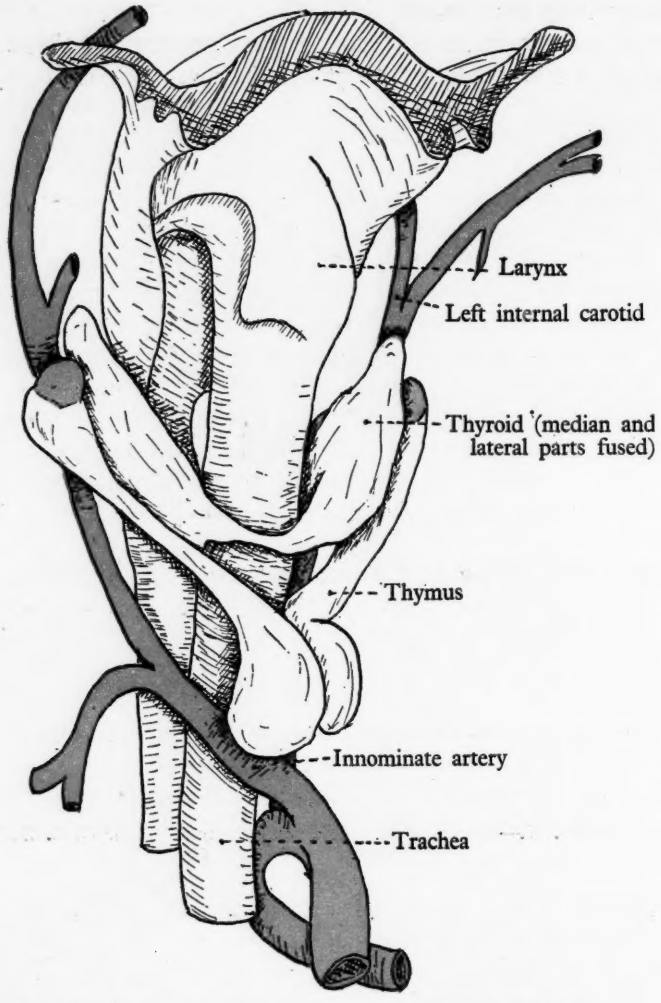

FIG. 13.—Human pharynx (23-mm. embryo). (*After G. L. Weller.*)
(Parathyroids coloured green.)

There can be no doubt that the occurrence of more than four parathyroids in the adult is frequent, and Kingsbury[12, 13] has commented on the embryology of these. He says: "In the 40-mm. embryo" (in the particular specimen which he had for the study of this stage) "there were four parathyroids on the right side, two extra bodies from their position being undoubtedly derived from III and IV. In the 18-mm. embryo there was a small accessory parathyroid III." These were isolated findings in the examination of a series of 60 embryos.

Parathyroid tumours have been reported in most of those sites which are embryological possibilities; they do not appear to have been encountered within the carotid sheath, between the artery and vein; and only two cases, of which one was regarded as a parathyroid carcinoma, have been reported in the region of the hyoid. Tumours may also be found embedded in the thyroid gland, presumably having been engulfed by the thyroid growth. Brewer[14] has reported the presence of normal parathyroid glands in the retro-sternal adult thymus, and on embryological grounds it appears likely that parathyroid tissue in this situation is more frequent than his isolated report of two cases would indicate. It is of interest that this arrangement is found fairly frequently in sheep.

Sir James Walton[1] considers that the site of a parathyroid tumour is determined by its position relative to the thyroid fascia, the tumours lying behind the thyroid fascia tending to descend into the superior mediastinum behind the œsophagus, whereas those lying between the thyroid fascia and the thyroid capsule pass like a retro-sternal goitre behind the manubrium. There can be no doubt that his conclusions are justified in the case of large tumours; indeed it would be difficult to explain a retro-œsophageal growth on embryological lines. Tumours so large as those in his third and fourth cases expand in the line of least resistance, and, favoured by the factors which produce retro-sternal goitre—e.g., deep inspiration and the muscular pressure set up in neck movements, they will take up a position in the loose areolar tissue behind the sternum or behind the œsophagus. But for the small retro-sternal parathyroid tumour the embryological explanation seems the more probable. Nor indeed do all big tumours descend, for a gigantic adenoma in one of Castleman and Mallory's cases[15] remained in the neck, pushing the thyroid forward.

Such are some of the embryological considerations guiding the parathyroids on their journey downwards, and one believes that they are not without practical importance.

SUMMARY

1. It may be necessary to split the sternum to find and remove an anterior mediastinal parathyroid tumour in hyperparathyroidism.

2. The cases of intra-thoracic parathyroid tumour have been collected.

3. An appeal is made to embryology to explain the bizarre sites in which parathyroid tumours have been found.

Our thanks are due to Professor H. A. Harris and Dr. Dixon Boyd, of Cambridge University Anatomy School, for criticism of the embryological section; to the staff of the Bland-Sutton and Courtauld Institutes, Middlesex Hospital, for the pathological and biochemical investigations; and to Dr. Graham Hodgson and his colleagues in the Radiology Department for the radiography undertaken in connection with the case.

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REPLACEMENT OF THE SEMILUNAR CARTILAGES OF THE KNEE AFTER OPERATIVE EXCISION *

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Removal of the semilunar cartilages (menisci) of the knee is undertaken with great frequency, and the surgeon is rightly disappointed if the function of the joint thereafter shows any gross departure from normal. Persistent pain, effusion, or limitation of movement is an occasional legacy of the operation, but, on the whole, it is true to say that the results of meniscectomy are amongst the best in the whole range of orthopædic surgery. The significance of this fact has not received its proper emphasis either in surgical teaching or in surgical literature; for it would seem to be a natural corollary that the menisci must regenerate or be substituted following excision, or else that they play an unimportant or even a dispensable role in the articular function.

The question of their regeneration or replacement is undoubtedly the most interesting of the many problems these structures provide, and the recorded observations on the matter are scanty and conflicting. This is so of the clinical evidence in particular; on the other hand, there is now a growing mass of experimental data, though there appears to be some reluctance on the part of the surgeon to absorb it into his teaching.

In this communication we propose to submit certain observations in support of the view that replacement of the excised cartilage occurs. The evidence is in part clinical, in part the result of some experimental work carried out some time ago.

THE FUNCTION OF THE SEMILUNAR CARTILAGES

The belief is current that the knee-joint functions as well without its cartilages as with them. Such a view surely depreciates the importance of the menisci in the normal economy of the joint, and it is perhaps germane to test its accuracy against the known function which the cartilages subserve.

Anatomical opinion on this point, unfortunately, is rather conflicting, and, as MacConaill (1932) points out, attempts have been made to explain the presence of the menisci along both morphological and functional lines. From the morphological side, they have been alternately regarded as persistent elements of the skeleton of lower forms; or as tendons or ligaments which have acquired an intra-articular situation. On the functional side, the main role ascribed to the menisci is that of adapting the incongruous surfaces of the femur and the tibia the one to the other, so that the weight transmitted through them is distributed over a larger area than would be the case were no cartilages present. By virtue of their elasticity, they also act to absorb part of the shock transmitted through them.

* The expenses of this work were defrayed by a grant from the Earl of Moray Endowment Fund, Edinburgh University.

It is difficult to conceive of the function of adaptation as providing the only explanation of the semilunar cartilages, for the accurate fitting of joint surfaces is secured without their intervention in most of the joints of the body. King's (1936) conclusion that the menisci serve for the protection of the articular hyaline cartilage is equally untenable. It is based on the experimental observation that, following removal of the menisci, degenerative changes ensue in the articular cartilage over the femoral and tibial condyles. It is difficult, however, to dissociate the inconstant changes he found from the possibility of operative trauma; but perhaps the most formidable argument against his theory is the fact that so few joints possess menisci.

By far the most interesting and in many ways the most important attempt to explain the menisci is that of MacConaill, who maintains that the cartilages are related primarily to the synovial fluid rather than to the articular surfaces. They induce during movement the formation of wedge-shaped films of synovial fluid in relation to the weight-bearing parts of the articular surfaces. Such wedges assist in the transmission of weight, and are necessary for the smooth working of the joint, while, by exerting counterpressure, they also prevent premature and violent contact between the articular surfaces. MacConaill has supported his contention by reference to mechanical and comparative anatomical facts, and his conclusions may be accepted as substantially correct.

If a difference of opinion exists concerning the exact function of the menisci, there is at least unanimity in regarding them as structures of some significance. It is difficult, therefore, to avoid the inference that a knee-joint completely deprived of them must be distinctly embarrassed. MacConaill, in particular, has investigated this aspect, and has formed certain conclusions. To him, the cartilages are accessories in the lubrication of the joint, and, to some extent, refinements on the part of Nature. Loss of the cartilages places the joint at a considerable disadvantage, in so far as it leads to about 20 per cent increase in friction during strenuous movements. In combination with the greater liability of the joint to concussion between the articular surfaces, this leads, first, to functional inadequacy of the joint during rapid movements or heavy exercise, and later, in many cases, to osteoarthritic changes. Fortunately, MacConaill's prediction is not altogether justified on clinical grounds, but the absence of such effects has occasioned very little surprise. Nevertheless, it seems clear, since the menisci play an important role in joint mechanism, that compensation for their loss must be effected in some way. MacConaill's argument omits the important possibility of the regeneration or substitution of the cartilages.

REGENERATION OF THE MENISCI: PREVIOUS CLINICAL OBSERVATIONS

Recorded observations on the regeneration of the menisci in man are scanty, and by no means conclusive. Sir Robert Jones stated in one of his Appendices to Timbrell Fisher's monograph on *Internal Derangements of the Knee-joint* that he had not personally encountered a case in which post-operative regeneration had taken place. Fisher himself supported this view and even went so far as to say that the discovery of a meniscus-like structure at a second operation on a knee formerly explored 'elsewhere' for a cartilage lesion was an indication of incomplete

removal. In a later contribution to the problem (1936), however, he reported two cases of his own in which regeneration had not only followed his original operations, but in which the regenerated cartilages had later been torn, necessitating further arthrotomy.

Mandl (1929) has also placed on record three cases in which an opportunity occurred to examine the knee-joint after partial or total medial meniscectomy. In two he was forced to re-open the joint because symptoms persisted, and in the third an opportunity for re-examination occurred when the patient succumbed to carcinoma of the bowel some four years after the cartilage operation. Mandl found in each case that a definite structure, showing the usual form of a semilunar cartilage, was present in place of the resected portion. In two cases the histological structure of this tissue was investigated and found to be similar to that of the normal meniscus; in each case it was firmly attached by its periphery to the capsule of the joint.

Moeller (1930), when he had subsequently to reopen a knee after medial meniscectomy, found a flat meniscus-like structure, which proved to be fibrous tissue, and which was attached at its anterior and posterior extremities only.

The only other reference to the matter which we have been able to trace is that of Gibson, but this cannot be taken as in any way conclusive. This author reported a case in which symptoms recurred after an operation on the medial side of the knee for an internal derangement of the joint which he supposed to have been a torn cartilage. When the joint was re-opened, Gibson found the meniscus *in situ*, and he concluded that regeneration had taken place.

These are, to date, the only clinical observations on the matter in surgical literature. The following case, therefore, is not without interest.

CASE REPORT

In August, 1935, a professional footballer sustained a knee injury, which was diagnosed as a tear of the medial meniscus. In October arthrotomy was performed, but the meniscus was apparently normal. The anterior portion, however, was removed. Following the operation symptoms persisted, and there was continuously an effusion in the joint. Re-examined in April, 1936, the symptoms and signs suggested a lesion of the external cartilage, and accordingly arthrotomy was again carried out by one of us (J. B.), on this occasion a badly torn lateral cartilage being removed. An opportunity was, however, provided by the laxity of the capsule and ligaments consequent on the effusion to inspect the anterior part of the upper surface of the medial tibial condyle, and a flat portion of tissue, identical in form with the anterior part of the meniscus, was found projecting into the interior of the joint from the capsule. The tissue was not attached posteriorly to the main bulk of the medial cartilage which had been left behind at the previous operation, nor was it attached to the tibia, so that it was easily removed. Its consistence was less than that of normal cartilage, and microscopic examination showed that it was composed of fibrous tissue.

In this case there can be no dispute that substitution had taken place, for the patient had been carrying about with him in a test-tube the anterior part of the medial cartilage which had formerly been removed.

THE EXPERIMENTAL EVIDENCE OF REPLACEMENT: PREVIOUS INVESTIGATIONS

The experimental evidence has been contributed by half a dozen workers. The most complete study is that by Lukjanov and Pokrovski (1929), who found

that in twenty-five dogs who survived meniscectomy the cartilages regenerated, irrespective of whether the removal was partial or complete. The regenerated structure was similar histologically to a normal semilunar cartilage. Pfab (1927, 1928) obtained less constant results. In sheep, following operation, a proliferation of the synovial membrane resulted in a flat meniscus-like structure, which lacked the typical histological structure of cartilage. In rabbits partial regeneration occurred in only 50 per cent of cases. Fiorni (1933) had more success, as frequently he encountered in rabbits replacement of the resected cartilages by fibrous tissue. Dieterich (1931) also found that after partial removal of the menisci in dogs the defect was obliterated by fibrous tissue.

In English, there are only two reports. Gibson (1930) found that five months after the removal of a part of the medial meniscus of a dog there was on re-opening the joint apparently complete restitution of the excised portion. The histological examination of the structure, however, showed that it consisted of fibrous tissue; there were no cartilage cells in it. King (1936) performed four complete, two sub-total, and two partial medial meniscectomies—in four dogs. In three of the dogs the joints were immobilized for eleven, seven, and three days, and all were re-opened eight to fourteen weeks later. In each case the extirpated cartilages were replaced by a semilunar disc of firm glistening tissue, which was grossly similar to meniscal tissue, but microscopically was composed of fibrous tissue.

Experimental excision of the cartilages has provided one other interesting fact. Dieterich found after partial removal that the knee constantly became the site of a proliferative arthritis, while King noted in every case a granular degeneration of the articular cartilages of both femoral and tibial condyles.

In summary, it may be said that, experimentally, a body of evidence exists which tends to show that, after removal, the semilunar cartilage is replaced by a flat fibrous structure attached peripherally to the capsule, and that clinically there is reason to believe—though the matter is not commented on in standard works—that replacement does occur.

THE PRESENT EXPERIMENTAL OBSERVATIONS

Excision of the lateral semilunar cartilage was undertaken in a series of six young dogs, the operation being conducted under the precise conditions that obtain in operations on the human subject. Thus the limb, previously prepared by shaving and by skin sterilization, was rendered bloodless by the application of a tourniquet. The incision employed was a slightly oblique one, beginning midway between the lateral edge of the patella and the lateral condyle, and passing downwards with a slight lateral inclination. It was in this way comparable to the usual incision in man, and the subsequent removal followed the usual lines, in that the anterior horn was first detached, then the peripheral connection to the capsule divided, and finally the posterior horn cut across. The cartilage was thus removed practically in its entirety, and the instruments used were replicas in miniature of those employed by many surgeons—Martin's forceps, Fairbank's and Martin's knives. The usual suture materials were employed in the repair of the capsule and skin. The operative procedure was in this way standardized and made to approach as nearly as possible the surgical ideal.

After operation the knee was tightly bandaged, and the tourniquet released. No attempt was made to immobilize the limb, and in each case the animal was bearing weight on it by the evening of the operation. By the following day the animals were all running about quite freely, and healing of the wounds took place by first intention.

Examination of the Replaced Cartilages.—The knee-joints of the six dogs were examined at periods varying from 149 to 357 days after the removal of the lateral semilunar cartilages. In each case the dog was destroyed and both hind legs were amputated one inch above the knee-joint. The lower part of the femur was then removed, care being taken during this procedure neither to disturb the semilunar cartilages nor to injure the articular surfaces of the bones. In all of the dogs the left leg was treated the same as the right (in which the cartilage had been removed), and its lateral semilunar cartilage and the articular cartilage of its bones were used as controls. The results of the six cases are summarized below.

Dog No. 1.—Right lateral cartilage removed July 9, 1934. Dog destroyed Dec. 5, 1934. Duration = 149 days.

The synovial membrane was hyperæmic. The replaced cartilage was complete in extent (*Fig.* 14), but was neither so thick nor so wide as the control. It was intimately connected with the articular capsule throughout. Anteriorly the cartilage was attached to the intercondylar area by a thin tendon.

FIG. 14.—*Dog No.* 1. Photograph of upper surface of right tibia with cartilages in situ. The replaced lateral cartilage is on the right of the figure.

FIG. 15.—*Dog No.* 1. Radiograph of replaced right lateral cartilage (left in figure) and control left lateral cartilage. A nodule of bone is seen at the anterior end of the replaced right cartilage.

After the cartilage had been freed from the tibia, a small hard nodule, with the consistence of bone, was felt in its anterior part, this portion being hinged to the main mass of the cartilage by a thin band of tissue. For this reason the cartilage was X-rayed (*Fig.* 15). On microscopic examination this nodule was found to be bone.

Dog No. 2.—Right lateral cartilage removed July 10, 1934. Dog destroyed Dec. 11, 1934. Duration = 154 days.

The lateral cartilage was complete in extent, but not so thick as the control (*Fig.* 16). The posterior end of the cartilage had the usual attachment to the posterior cruciate ligament.

After removal, the cartilage was felt to have a firmer consistence than the normal semilunar cartilage, and did not possess its lustre.

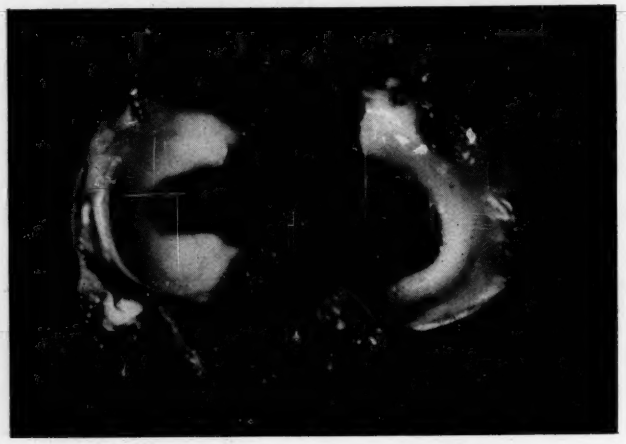

FIG. 16.—*Dog No.* 2. Replaced right lateral cartilage (right of figure) and control left lateral cartilage.

Dog No. 3.—Right lateral cartilage removed July 10, 1934. Dog destroyed Dec. 18, 1934. Duration = 161 days.

On exposure of the upper surface of the tibia the lateral semilunar cartilage seemed to be absent except for an anterior tag that was attached to the intercondylar area. The synovial membrane of the entire joint was greatly injected, but most so on the lateral side. On microscopic examination a small eminence was found to project medially from the inner surface of the capsule, and this consisted of fibrous tissue.

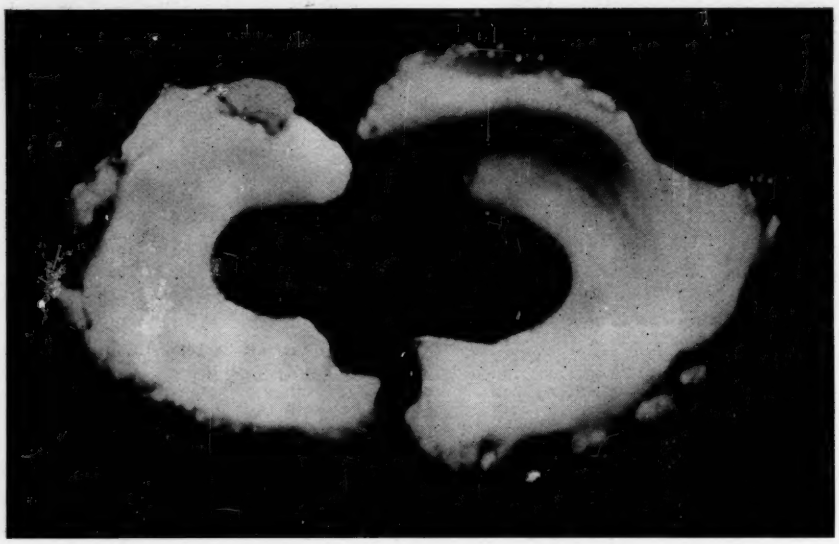

FIG. 17.—*Dog No.* 4. Replaced right lateral cartilage (right of figure) and control left lateral cartilage.

Dog No. 4.—Right lateral cartilage removed July 9, 1934. Dog destroyed Jan. 8, 1935. Duration = 182 days.

The synovial membrane on the lateral aspect of the joint was markedly injected. The lateral cartilage was complete in extent (*Fig.* 17), but was thin and translucent. The anterior part of the cartilage had a diffuse attachment to the intercondylar area, but posteriorly there was no attachment to the tibia.

Dog No. 5.—Right lateral cartilage removed July 10, 1934. Dog destroyed March 1, 1935. Duration = 234 days.

The synovial membrane was hyperæmic. Only about three-quarters of the original cartilage had been replaced, the anterior quarter being absent (*Fig.* 18). The articular cartilage of the exposed portion of the tibia was of a normal appearance. The anterior end of the cartilage had no attachment to the intercondylar area, but a fibrous band connected it with the capsule. The posterior end of the cartilage was attached to the posterior part of the intercondylar area. In the anterior part of the cartilage there was a small hard nodule, and this part was connected to the main mass by a thin bridge of fibrous tissue. The periphery of the entire cartilage was connected with the capsule.

FIG. 18.—*Dog No.* 5. Replaced right lateral cartilage.

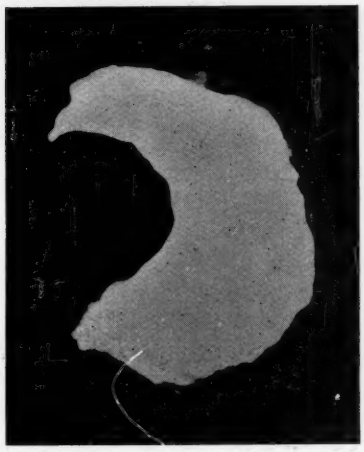

FIG. 19.—*Dog No.* 6. Replaced right cartilage.

Dog No. 6.—Right lateral cartilage removed July 10, 1934. Dog destroyed July 3, 1935. Duration = 357 days.

The synovial membrane was not hyperæmic as in the other dogs. The replaced cartilage was complete in extent and width, but not so thick as the control (*Fig.* 19). It was extremely adherent to the capsule, and both its anterior and posterior ends were attached to the intercondylar area. It did not possess the lustre of the control cartilage.

Summary of Experiments.—In five of the six dogs where the lateral semilunar cartilage had been removed a complete or partial replacement was observed when the femur was disarticulated. In the sixth case the regeneration was only obvious in microscopic sections of the lateral portion of the articular capsule. Although the terms 'replaced' or 'regenerated' cartilage have been used throughout this work, it must be stressed that in all cases the new element was formed of fibrous tissue, and fibrous tissue alone (*Fig.* 20), and that in no instance were cartilage cells observed. The fibrous-tissue cells were relatively greater in number

in the region of the concave inner margin of the substituted disc (*Fig.* 21) than elsewhere, indicating the increased activity of this part of the regenerating mass.

FIG. 20.—Photomicrograph of section of replacing tissue.

FIG. 21.—Photomicrograph of section of central growing edge of replaced cartilage, showing increase in number of cells.

In all cases, with the exception of *Dog No.* 6, the articular capsule showed a variable degree of hyperæmia, the degree of injection being inversely proportional to the

size of the regenerating mass. Associated with this last factor was the invariable continuity of the regenerating cartilage and the capsule of the joint, and these two

FIG. 22.—Photomicrograph of section of bone nodule.

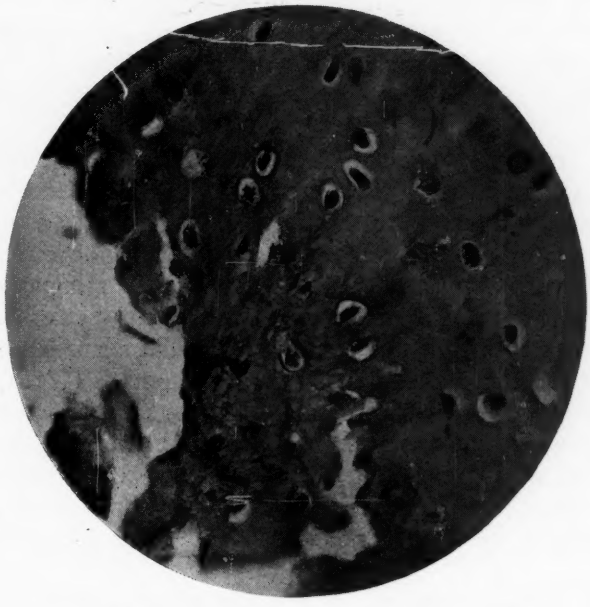

FIG. 23.—Photomicrograph of section of bone nodule.

facts appear to substantiate the view that the new elements are derived from the articular capsule.

The growth in width of the replaced cartilages—i.e., the growth towards the interior of the joint—was in all instances relatively greater than the growth in thickness. This was most obvious in *Dog No.* 6, where the regenerated mass was even broader than the control, but only a little more than half its thickness. With the exception of *Dog. No* 3, the size of the regenerated cartilage had a distinct relationship to the time that had been allowed for regeneration, although there was no direct ratio between size and time. It can be stated, however, that in the dog a meniscus of complete semilunar form, though of smaller volume than the control, can be regenerated within five months, and that within one year there can form a meniscus that is complete in its antero-posterior extent and its width, although deficient in its thickness. The fact that the lateral meniscus in *Dog No.* 3 was still only of microscopic size, even after a recovery period of 161 days, demonstrates the great individual variation in the rate of regeneration.

In *Dogs Nos.* 1 and 5, small nodules of bone were found in the semilunar cartilages (*Figs.* 15, 22, and 23). In each case the bone was at the anterior ends of the cartilages, and was surrounded by typical fibrocartilage. Moreover, each bony segment was connected to the main body of the cartilage by a thin bridge of fibrous tissue. For these reasons it is assumed that the heterotopic bone has formed in the small remnants of the anterior horns of the original cartilages, and not in the regenerative masses that are composed of fibrous tissue.

DISCUSSION

Certain significant issues are raised by these experiments. It is probable that the good function of the knee following meniscectomy is due to the fact that the menisci are replaced by fibrous discs, which resume their function as lubricating accessories, and are in all likelihood just as efficient. This fact, we feel, has some practical importance in relation to the operation of meniscectomy in the human subject.

1. Partial Transverse Tears of the Menisci.—In the operative treatment of partial tears of the menisci the practice of individual surgeons has formerly varied. Some regard the removal of the whole cartilage as essential in all cases, while others are content with the resection of the torn portion only. It seems to us that the arguments favour total meniscectomy. In the partial operation it is easy to imagine that no very effective union would take place between the substituted part and the stump; that overlapping, with the formation of a nodular area, might ensue, and be the cause of persistent symptoms. This, to some extent, is borne out by the clinical experience we record in the earlier part of the paper, for in this case the replacing disc was completely separate from the remainder, and the effect of the cartilage in regulating the synovial fluid pressure must have been largely lost. Complete meniscectomy, on the other hand, is likely to be followed by the appearance of an even, smooth disc, of equal effectiveness in the joint function.

There is, of course, a clinical, as opposed to an experimental, argument for total meniscectomy. The condition of the posterior horn cannot be properly determined through the anterior arthrotomy incisions, and if left behind in a traumatized condition, symptoms are prone to arise. It is our suggestion that symptoms in some cases may be due to ineffectual or unsatisfactory union between

the stump of the original and the replacing meniscus, and the experimental findings are, therefore, a further argument in favour of the complete removal of injured cartilages.

There is, perhaps, one further point of some interest. The regenerated semilunar cartilage is a product of the capsule, and is inseparably joined to it. It is therefore actually in a stronger position than the normal cartilage as regards displacement.

In urging total meniscectomy we are at variance with King (1936), who encountered degenerative changes in the articular cartilages, which were more prominent after the more complete removals. We are unable to confirm the occurrence of degenerative changes; and, since King failed to obtain regeneration in his last series of lateral cartilage cases, it seems at least possible that technical considerations may explain the discrepancy.

2. The 'Mobile' or Dislocated Cartilage.—The condition of 'mobile' cartilage calls for special comment. In this lesion, although it appears at first sight as if the whole cartilage slips into the interior of the joint, the majority of surgeons are aware that the cartilage is actually torn in its substance, leaving a peripheral strip applied to the capsule. The temptation to remove only the mobile portion is great. King, however, has made it quite clear by experiment that a peripheral rim of true cartilage prevents the formation of a new disc by the capsule. In mobile cartilage, therefore, it would seem advisable also to remove the peripheral stump.

3. The 'Bucket-Handle' Tear.—Similar considerations arise in connection with the 'bucket-handle' type of tear. Although it has been suggested that it is only necessary to remove the 'handle'—the inner, separated part of the meniscus—experimental observations indicate that for perfect substitution the cartilage must be removed in its entirety, and the peripheral separation carried out as close to the capsule as possible.

CONCLUSIONS

1. After meniscectomy, the semilunar cartilage is replaced.
2. The substituted structure is composed of fibrous tissue, and it is an ingrowth from the articular capsule.
3. In outline and position it exactly corresponds to the normal cartilage, but in dogs, even after a year, it is not of normal thickness.
4. Although in general the amount of growth is proportional to the length of time elapsed since meniscectomy, there is considerable individual variation.
5. Complete rather than subtotal meniscectomy is advisable, as a more even substitution then results.

In conclusion, we should like to express our gratitude to Professor Sir John Fraser for permission to treat the patient mentioned in the report, and for his interest; and to Professor Brash for his encouragement, and for the facilities afforded by his department. We should also like to thank Mr. David Smith for the preparation of the microscopical material, and Mr. John Borthwick for the photography.

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POST-OPERATIVE BLOOD LIPIDS*

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INTRODUCTORY

In recent years there has arisen considerable interest in the effect of various surgical procedures upon the metabolism of the body as revealed through chemical analyses of blood. Many of the results to date have proven of practical as well as of academic interest. Amongst those phases of metabolism studied have been included a few investigations of certain aspects of lipid metabolism. A further stimulus to the study of blood lipids following surgical operations has been the attempt to discover thereby information concerning the ætiology of traumatic fatty embolism.

The blood lipids are made up of four groups of substances. Firstly, there are the neutral fats, which are compounds of glycerol with three identical or different fatty acids, and which are also known as triglycerides. The second group includes the phospholipids, of which there are several types, the simplest of which have a group made up of phosphoric acid and a nitrogenous base in place of one fatty acid in the neutral fat structure. The substitution of this for the fatty acid renders the molecule relatively more 'soluble' in an aqueous medium such as blood-plasma, and the presence of phospholipids in plasma permits of the uptake and colloidal solution of more of the insoluble neutral fats, cholesterol, and cholesterol esters. Cholesterol esters comprise the third group, and are combinations of cholesterol, which is a sterol or higher alcohol, and thus an organic base, with a fatty acid. There are approximately equal parts of each of these groups in the plasma of a normal human adult, and together they comprise 90 per cent of the lipids present. The remaining 10 per cent, the fourth group, is composed of one substance, cholesterol—or 'free cholesterol' as it is usually termed, to distinguish it from cholesterol in the ester form or 'ester cholesterol'. Cholesterol is the only known sterol in blood, and its sole established relation to lipid metabolism is its capacity of joining with fatty acids to form cholesterol esters.

The red blood-cells contain the same groups of lipids but in different proportions. Approximately 60 per cent of the lipids present are phospholipids, 20 per cent is free cholesterol, and 20 per cent cholesterol esters plus neutral fat. Owing to the unequal distribution of lipids between plasma and the red blood-cells, and also to the fact that variations in the concentration of blood lipids generally occur in plasma only, an analysis of plasma or of serum is to be preferred to one of whole blood.

No complete differential analyses of blood lipids in relation to surgery in general have hitherto been made. A few authors have estimated the 'total lipid' content of blood before and at intervals after operations. Their procedure has in general been to determine the amount of material extractable by petroleum

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ether or benzine, using the Bang-Bloor technique. The impression one obtains from a survey of their conclusions is that they believe there exists a post-operative lipæmia which is of moderate extent and not necessarily exceeding the normal limits, i.e., it may be a relative lipæmia. One purpose of the present communication is to demonstrate that surgical operations of themselves are not responsible for a post-operative lipæmia. It will be shown that there are a number of factors conducive to the development of a lipæmia post-operatively, but that this is due to the removal of certain tissues or organs at, or to the correction of some pathological state by, operation, and not to the operation itself.

Killian[17] has presented a lengthy and exhaustive survey of the literature on traumatic fatty embolisn. In five operations on bone he found that there occurred an increase in the concentration of 'Blutfett' following the operation. Von Seemen,[21] using blood obtained by the finger-prick method, recorded a lipæmia immediately after operation, which was probably the effect of the anæsthetic, followed by a lipopenia at 1 to 4 days, and then a gradual increase to normal by the end of the first week or ten days. Popper and Scholl[19] confirmed the findings of von Seemen by demonstrating a lipæmia due to ether narcosis in 7 out of 8 cases, followed by a lipopenia at the 2nd to 4th day post-operatively in 4 out of 6 cases. They[19] also found a tendency toward higher values for 'Blutfett' in fracture cases. Vogel[22] presented data obtained from 50 cases; no significant change in the fat content of blood was noted by the end of the first hour post-operatively, but by 48 hours there had occurred an increase in 10 out of 13 cases studied again at that time. Prochnow and Findeisen[20] reported fewer cases but a more complete study of each, and were able to show that, apart from the immediate effects of the anæsthesia, the late effects of surgery varied from case to case; one group of 4 cases showed no changes at all, another group of 4 cases exhibited fluctuations, and a third group of 6 cases revealed a prolonged lipæmia relative to the pre-operative values.

In addition to these studies on the whole petroleum-ether extractable material of blood, several authors have reported on blood-cholesterol. In these researches the value reported was total cholesterol, which includes both the free and combined forms of the sterol. Maxwell[18] described 5 cases in THE BRITISH JOURNAL OF SURGERY in which he found that 3 to 5 weeks after operations in the field of genito-urinary surgery there was either a slight increase or no change in the concentration of plasma-cholesterol. Other reports by Dietel[15] and by Driessens and Souchon[16] indicate that the earlier effects consist in a tendency toward low values for cholesterol in the first week post-operatively. It is difficult to determine if these latter authors considered sufficiently the possibility of these changes being due to fever, which of course would have had a lipopenic effect also.

Apart from these few studies on total fat and total cholesterol little is known concerning the possible effect of surgery itself on blood lipids. Nothing has been recorded on the concentration of other of the component lipids. No attempt has been made to investigate the partition of lipids between plasma and the red blood-cells. Whether or not the type of operation is a factor has not received attention, except that a few of the above authors have separated operations on bone and laparotomies from operations in general. Secondary conditions such as fever and toxæmia have not been considered. The present investigation represents an attempt to fill in a number of these gaps in our knowledge.

MATERIAL AND METHODS USED IN THE PRESENT INVESTIGATION

The conclusions reached herein were based upon the results obtained from a study of 29 cases in which blood was analysed before and from one to five times after operation. In the majority of instances the patient had fasted over night previous to the drawing of blood. Since all patients were hospitalized, ingestion of excessively large meals rich in fat did not have to be considered, and it is only such large meals which affect blood lipids levels; ordinary meals do not.[5] In the earlier cases studied potassium oxalate was used as an anticoagulant, and in the later cases heparin. Boyd and Murray[13] have shown that potassium oxalate produces an immediate dilution of plasma lipids and a concentration of lipids in the red blood-cells, but that after 6 to 8 hours diffusion sets in, and by 24 to 48 hours the original values have been restored. The same anticoagulant was used for all samples of blood from the same patient, and extracts were made in less than 6 hours after drawing blood. Hence none of the changes recorded could have been due to alterations produced by the anticoagulant.

The samples of blood were centrifuged at full speed for one hour and extracts made of both plasma and of the red blood-cells. Over 150 extracts were made, and analysis of these yielded over 1500 lipid values. The earlier extracts were prepared by boiling the alcohol-ether after the manner of preparing the usual Bloor extract. The later extracts were prepared by cold dilution upon the principles developed by Boyd for plasma[7] and for the red blood-cells.[8] Extracts so prepared were analysed by the oxidative micromethods of Bloor as modified by Boyd.[1, 2] In each extract the following substances were determined: total lipid, neutral fat, total fatty acids, phospholipid fatty acids, cholesterol ester fatty acids, neutral fat fatty acids, total cholesterol, ester cholesterol, free cholesterol, and phospholipid.

RESULTS

Examples will be taken from the different groups of cases studied in order to illustrate the effect of various surgical procedures upon the concentration of lipids in human blood.

Uncomplicated Extra-abdominal Surgery.—In *Fig.* 24 have been plotted values for plasma lipids in a case in which a repair was made of the pelvic floor, including repair of a cystocele and rectocele and a perineorrhaphy, in a woman of late middle age with a relaxed pelvic floor. This case is presented as typical of results obtained in extra-abdominal operations in which no structure known to influence blood lipids is removed or otherwise affected, and in which fever is absent throughout. In this case blood was analysed pre-operatively, and on the first, fifth, and thirteenth days post-operatively.

It may be noted from *Fig.* 24 that there occurred fluctuations in the concentration of all plasma lipids at twenty-four hours after operation, the net trend being lipopenic. These fluctuations within the first day are believed to be due to the effect of the general anæsthesia, which in all cases herein reported was ether. Boyd[9] has shown that there occurs a temporary increase in the plasma lipid content a few hours after an anæsthetic, followed by a lipopenia in plasma at twenty-four hours. At the same time opposite changes of greater extent set in in the red blood-cells, and these latter are the determining factors in analyses of whole blood.

That is to say, twenty-four hours after anæsthesia analysis of whole blood reveals a lipæmia relative to the original pre-anæsthetic values.

Aside from these fluctuations which may be ascribed to the effect of general anæsthesia, it is obvious from *Fig.* 24 that this operation had no further effect upon the concentration of plasma lipids. Such may be taken as typical of all operations of this type. Plastic surgery wherein no endocrine gland or other lipotropic structure is removed as either a healthy or diseased organ, has no effect upon the concentration of plasma lipids providing no fever ensues.

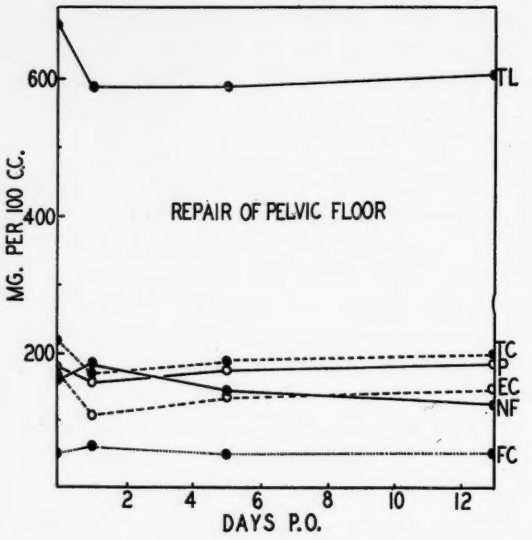

FIG. 24.—Plasma lipids following repair of a relaxed pelvic floor. Symbols: TL, Total lipid; TC, Total cholesterol; P, Phospholipid; EC, Ester cholesterol; NF, Neutral fat; FC, Free cholesterol.

A graphic representation of the results obtained in analyses of the lipid content of the red blood-cells in the above case has not been prepared. The only significant changes in the lipid content of these cells in the case presented in *Fig.* 24 were marked increases at twenty-four hours post-operatively, followed by a return to normal values during the remainder of the convalescence. The day after operation there was found a marked increase in the neutral fat, ester cholesterol, and phospholipid content of the red blood-cells, resulting in increases also in total cholesterol and total lipid. At this time the total lipid value was almost double that pre-operatively. These changes, as stated above, are believed to be due to the effect of the ether anæsthesia.[9] On the 5th and 13th days post-operatively the percentage of lipids in the red blood-cells was almost identical with that before operation.

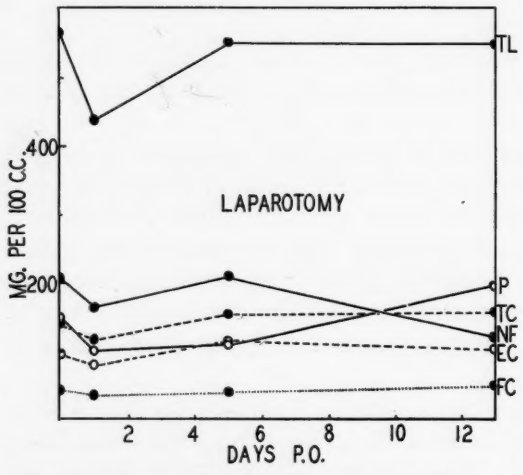

FIG. 25.—Plasma lipids following unilateral oöphorectomy and salpingectomy. Symbols as in *Fig.* 24.

It may be concluded, therefore, that operations of this type have no effect upon the lipid content of either plasma or of the red blood-cells apart from the immediate effect of the general anæsthesia.

Abdominal Surgery.—Certain of the authors referred to above separated their cases into abdominal and extra-abdominal, giving rise to the implication that they considered that there might be a difference between the two with respect to their effect upon the values of blood

lipids. This has not been found to be the case in the present investigation. In *Fig.* 25 have been depicted the analyses of plasma in a case in which an oöphorectomy, salpingectomy, and appendectomy were performed on a woman with a benign ovarian tumour. The results resemble those presented in *Fig.* 24. At twenty-four hours post-operatively there occurred a lipopenic change in plasma, following which the values returned to normal and remained so. There was somewhat more variation in the concentration of plasma neutral fat and phospholipid than in the case represented in *Fig.* 24. Such fluctuations are probably of no significance, since they did not consistently appear in the other cases studied.

The concentration of lipids in the red blood-cells in this case followed a course similar to that of the previously described case. The day following operation the lipid content of the red blood-cells was elevated, but later returned to the pre-operative values and remained so.

These results have therefore failed to demonstrate any significant difference between abdominal and extra-abdominal surgery with respect to blood lipids. Except for the influence of the general anæsthesia, operations of both types have no effect upon the concentration of lipids in either plasma or in the red blood-cells.

Febrile Cases.—It would appear that the conception of a post-operative lipæmia, which is a misconception, has arisen largely from a study of cases in which operation was performed upon patients with fever. In such cases recovery from fever to a normal body temperature will of itself produce a rise in the concentration of lipids in plasma. Fever of various causes is accompanied by a decrease in plasma lipid values, and hence the condition is termed the lipopenia of fever.[6] The cause of this lipopenia is apparently not the elevated body temperature *per se*. Boyd, Orr, and Reed[14] found that normal variations in the body temperature of healthy rabbits were not accompanied by corresponding changes in the lipid content of plasma.

That fever is a factor influencing post-operative blood lipid values is seen in the case depicted in *Fig.* 26. In this figure have been plotted values for plasma lipids following a posterior colpotomy in a woman with a pelvic abscess which followed upon an induced abortion that had taken place some two months previously. The pre-operative values for all plasma lipids except neutral fat were considerably below normal, the typical picture of a lipopenia of fever. Following operation the temperature of the patient fell slowly, but did not reach normal until the 10th day. The gradual fall in body temperature was accompanied by a rise in plasma lipid values. There were some fluctuations, but in general the concentration of all lipids and of total lipid rose until at 10 days post-operatively they were almost within the normal limits.

It would be quite incorrect to attribute this lipæmic change to surgery itself. In this case surgical interference, by removing the cause of fever, permitted recovery from fever, and under the circumstances this latter appears the most logical explanation of the lipæmic change, since convalescence from fever itself is accompanied by a relative lipæmia.[6]

The case illustrated in *Fig.* 27 is even more exemplary of this type of post-operative convalescence. This case was one of prostatism with retention of urine and fever. The results depicted in *Fig.* 27 are plasma lipid values following the first stage of the operation, namely, drainage of the bladder. Convalescence from this operation was accompanied by a gradual return to normal body temperature,

fever ceasing by the 10th day. The initial pre-operative plasma lipid content was low, total lipid being under 300 mg. per cent. As fever subsided the concentration of plasma lipids gradually rose until by the 12th day, after two days without a febrile temperature, the plasma lipid content was within the normal range.

It is quite obvious that if the factor of fever were neglected the results of this case might be taken as evidence of a post-operative lipæmia. In view of the foregoing considerations, the most likely interpretation of the results is that they were due to the removal of the febrile reaction.

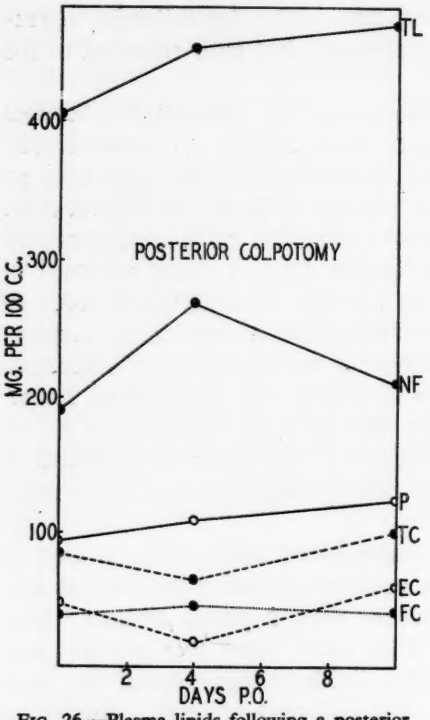

FIG. 26.—Plasma lipids following a posterior colpotomy. Symbols as in *Fig.* 24.

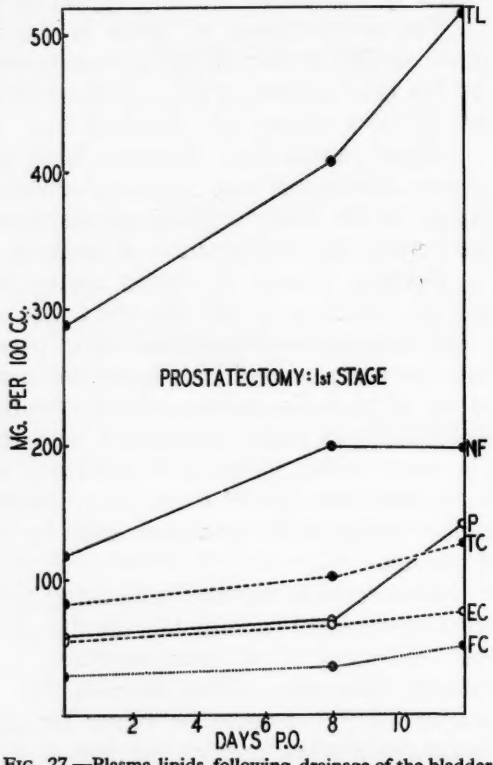

FIG. 27.—Plasma lipids following drainage of the bladder as first stage of a prostatectomy. Symbols as in *Fig.* 24.

While these changes were taking place in the plasma of the case illustrated in *Fig.* 27, there occurred a progressive decrease in the phospholipid and free cholesterol content of the red blood-cells. Phospholipid declined from a pre-operative value of 327 mg. per cent to 248 mg. per cent, and free cholesterol from 121 mg. per cent to 109 mg. per cent. There were no consistent changes in the values for ester cholesterol and neutral fat, which were low throughout. As a result the total lipid and total cholesterol content of the red blood-cells likewise decreased post-operatively. This series of changes is analogous to what is encountered in convalescence from fever,[6] and the analogy suggests that fever rather than surgery *per se* is the determining factor responsible for the events noted.

Non-febrile Toxæmia.—The absorption of toxic material from sequestered pus frequently gives rise to a toxæmic condition in which there need be little if any temperature. Drainage of such pus sacs remedies the condition. An example

of this type of case is illustrated in *Fig.* 28, in which are depicted plasma lipid values following a posterior colpotomy to drain a pelvic abscess which had given rise to a very low-grade fever. The patient's temperature returned to normal almost immediately after operation, but pus continued to drain away for two weeks. Coincident with the decline in temperature, there occurred an increase in the concentration of plasma lipids to higher than normal values. After this, as pus continued to drain away, plasma lipids gradually fell to normal. It would appear that in this case the chief factor affecting the plasma lipid values was the toxæmia resulting from absorption of pus rather than from the fever. At no time was there a lipopenia, as one would expect if fever were the controlling factor. In fact the values were slightly lipæmic, which suggests that toxic absorption of this sort may give rise to a lipæmia. Removal of the source of the toxæmia then results in a fall to normal in the lipid content of plasma.

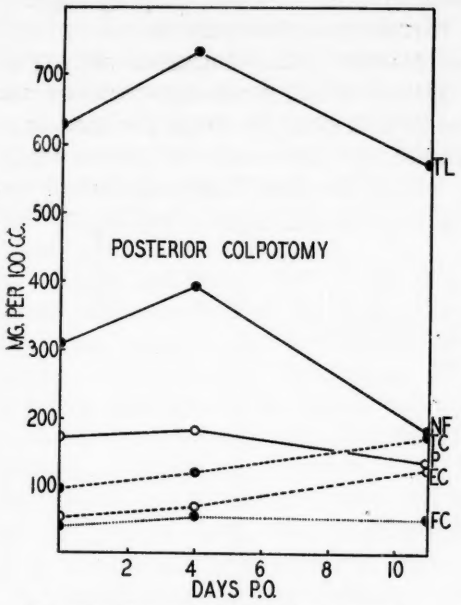

FIG. 28.—Plasma lipids following a posterior colpotomy. Symbols as in *Fig.* 24.

Completion of Abortion.—We may proceed next to a consideration of surgery in which some structure is removed which had previously been influencing the level of blood lipids. One such condition is pregnancy.[3] Surgical interference in early pregnancy may be expected to have a lipopenic effect upon plasma lipids if gestation is thereby stopped after having progressed to a point at which it has produced a lipæmia. An example of such a case is illustrated in *Fig.* 29, which depicts plasma lipid values following completion of an abortion self-induced a few days previously in a young woman. In this case surgical interference was followed by a decline in the percentage of plasma lipids. There were some fluctuations, but in general the values fell. The obvious conclusion is that the effects recorded were due to the cessation of pregnancy rather than to surgery *per se*. The lipid content of the red blood-cells was not significantly changed at any time in this case. Surgical interference at or near the termination of pregnancy is

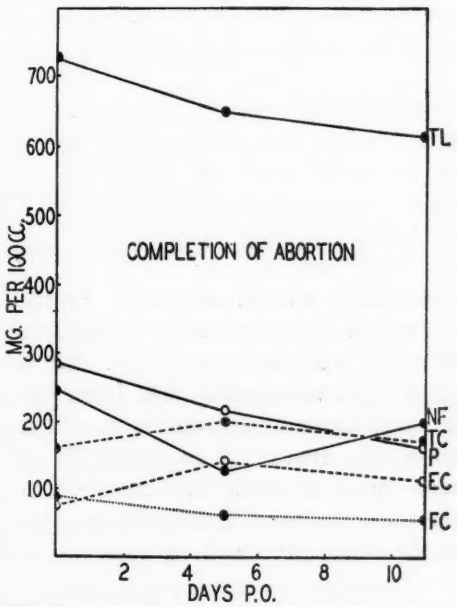

FIG. 29.—Plasma lipids following a completion of an abortion. Symbols as in *Fig.* 24.

invariably accompanied by a fall in plasma lipid values in a manner similar to that recorded by Boyd[4] as characteristic of the normal puerperium in woman, providing of course that the interference results in the cessation of pregnancy.

Thyroidectomy.—The secretion of the thyroid gland has been shown by Boyd and Connell[12] to control the concentration of plasma lipids. Increased activity of the thyroid lowers the concentration of the plasma lipids, producing the lipopenia of hyperthyroidism. Decreased activity of the thyroid gland results in the lipæmia of hypothyroidism. In *Fig.* 30 have been depicted the percentages of plasma lipids in a case following partial thyroidectomy in which the gland removed showed the

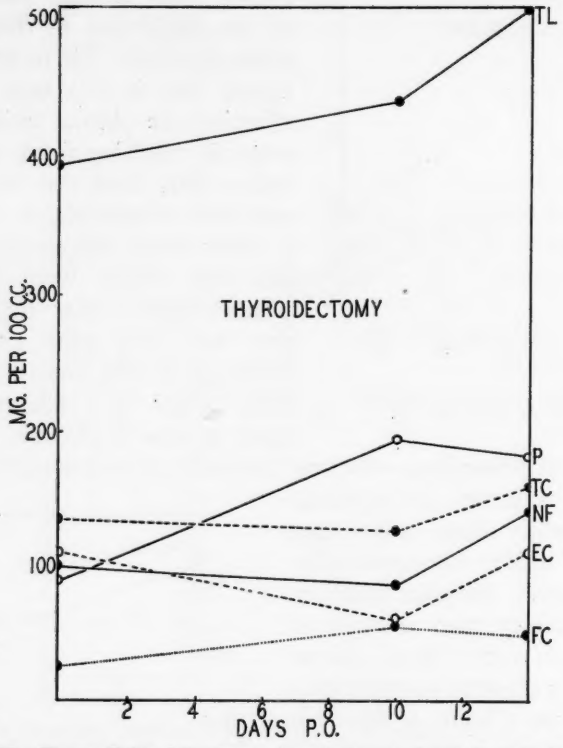

FIG. 30.—Plasma lipids following a thyroidectomy. Symbols as in *Fig.* 24.

presence of a fœtal adenoma. Operation was followed by an increase in the concentration of plasma lipids. The factor most obviously responsible for the changes recorded was the removal of the thyroid gland. The effect of thyroidectomy upon lipid metabolism has been previously discussed.[10] This case is presented as an example of operations in which part or all of glands of internal secretion are removed. Inasmuch as practically every one of the endocrine glands studied has been found to affect lipid metabolism either directly or through some other gland, variations in blood lipids after surgery of this type must be interpreted in the light of the effect produced by removal of the gland in question.

DISCUSSION

These various cases have been presented in order to demonstrate that an effort should be made to eliminate all predisposing factors before concluding that

surgical operations themselves may influence the concentration of blood lipids. It has been shown that ether anæsthesia is the predominant factor responsible for changes in the concentration of plasma and red blood-cell lipids during the first day or so after operations in which this anæsthesia is used. When operative procedures are accompanied by variations in body temperature, these latter may affect the concentration of blood lipids independently of the surgery. The introduction of a toxæmic factor may also affect blood lipid values apart from any concomitant surgical interference. The removal of all or part of a structure such as a fœtus, or of an organ producing an internal secretion such as the thyroid gland or the placenta or presumably the prostate, may sufficiently alter lipid metabolism to affect blood lipid values.

These are but a few of the factors which must be considered. There are many other conditions which are known to influence the concentration of blood lipids and probably many which are unknown. It is not the purpose of the present paper to review such conditions. Diabetes, however, may be mentioned, since a recent case seen by the author exemplified the necessity of recalling this condition to mind in interpreting post-operative plasma lipid values. This case was of a young woman of apparently previous good health who sustained a ruptured appendix. In spite of the subsequent fever and other complicating factors, the concentration of the plasma lipids was found to be almost three times the average normal. Simultaneously a glycosuria was found and an elevated blood-sugar, and a diagnosis of diabetes mellitus was made.

Post-operative pulmonary œdema is not a common condition, but when it occurs it may have a pronounced effect upon the concentration of plasma lipids. In this condition the sudden concentration of plasma by removal of large amounts of fluid into the lungs and other structures produces a secondary polycythæmia and an increase in the concentration of lipids in plasma. This condition has been recently discussed by the author[11] in conjunction with a consideration of blood lipids in polycythæmia vera.

Post-operative cases in which no contributing factor can be established are usually found to have no significant alteration in the percentage of blood lipids, either those of plasma or of the red blood-cells. This has been found in the present investigation to hold true for major as well as minor operations, either within or without the abdomen. There seems, therefore, no further justification for the use of the term 'post-operative lipæmia', or for the postulate that such a condition may exist and be due to surgery itself.

SUMMARY

The concentration of total lipid, neutral fat, total cholesterol, ester cholesterol, free cholesterol, and phospholipid in blood plasma and in the red blood-cells was determined by oxidative micromethods in 29 cases before and from one to five times after operation.

Recovery from fever post-operatively was found accompanied by a relative lipæmia; removal of the thyroid gland, placenta, fœtus, or of the products of toxic origin produced a relative lipopenia. Other predisposing factors are discussed.

When no contributing factors such as these were found present, surgical interference *per se* was found to have no effect upon the concentration of blood lipids. There is no justification for postulating the condition 'post-operative lipæmia'.

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CHRONIC MASTITIS IN THE AFRICAN NATIVE: ITS RELATION TO CARCINOMA OF THE BREAST

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THE ætiology of chronic mastitis and its prognosis are still subjects for controversy throughout the world, and the literature is extensive. My excuse in adding to it is that as far as I know the material forming the basis of this paper has never been studied for this purpose before, and I think it throws light on the subject from a new angle. The work carried out is similar to that described by F. d'Abreu,[1] to whom I make my acknowledgements. It was done at the Bida Native Administration Hospital, Nigeria. The people attending the Hospital are largely Nupes, but there are also Yorubas and Hausas. These races, although in most respects different culturally, have this in common, that they feed their children at the breast for 2 to 3 years after birth.

The Nupes have until recently been resistant to European medicine: a considerable length of residence was required before enough confidence was established to enable examinations to be made. In addition, no examinations were made of women with babies at the breast. These two factors reduced the material available during my time of residence, but sufficient work has been done, I think, to enable conclusions to be drawn.

In all 140 women were examined, consisting of 125 Nupes, 10 Yorubas, and 5 Hausas. The special points looked for in examination and history were: (1) Presence of nodularity in the breasts; (2) Presence of cysts in the breasts; (3) Menstrual history; (4) Reproductive history; (5) Presence of pain in the breasts at menstruation.

CLINICAL FINDINGS

The following are the findings under the headings given above.

1. Presence of Nodularity in Breasts.—Out of 140 women examined, 72 were found to have nodularity of the breasts—that is, 51 per cent.

Accurate classification according to age groups was not possible, for no adult native has really any idea of age. An estimate was therefore made from all available evidence as to whether the woman was over or under 30 years, and three groups were formed:—

i. Puberty to 30 years: 57 cases, 30 with nodularity (52·6 per cent).
ii. Thirty years to menopause: 46 cases, 25 with nodularity (54·3 per cent).
iii. Post-menopausal: 37 cases, 17 with nodularity (46 per cent).

In 42 cases nodularity occurred on both sides; in 19 cases it occurred on the right side only; in 11 cases it occurred on the left side only.

2. Presence of Cysts in Breasts.—Unmistakable cysts were present in 20 cases.

The age distribution according to the grouping given above, was: (i) Seven cases (12·2 per cent); (ii) Six cases (13 per cent); (iii) Seven cases (19 per cent).

The cases varied from those with a single cyst to those with numerous cysts on both sides.

3. Menstrual History.—Inquiry into the menstrual history showed no appreciable differences between women with nodularity and those without. D'Abreu's finding that as a rule women showing nodularity had scanty, painful periods was not confirmed.

4. Reproductive History.—No significant relation was found between the incidence of nodularity and the number of children. But the number of cases was really too small for conclusions to be drawn in this respect.

5. Presence of Pain in the Breasts at Menstruation.—In the 103 women between puberty and the menopause, 19 complained of pain in the breasts at menstruation: 13 of these showed nodularity, and 6 showed no nodularity. Pain is therefore probably unrelated to nodularity.

DISCUSSION

In d'Abreu's paper[1] he stated that he found nodularity in 114 out of 500 women examined, i.e., 23 per cent. The figures given above show that in Bida nodularity is about twice as common as in England. My figures for age groups correspond with his in that the incidence of nodularity grows less after the menopause. But even so, the percentage incidence is still very high.

The incidence of cysts is much higher also: 20 out of 140 as compared with 20 out of 500. D'Abreu believes that the pre-menstrual proliferative activity seen in the breast and called by Cheatle 'mazoplasia', may, if ovarian function be deficient, fail to undergo the usual post-menstrual involution and then may gradually pass into permanent nodularity with epithelial hypertrophy and cyst formation (Cheatle's 'cystiphorous hyperplasia'). The findings given above appear to show that if chronic mastitis is related to ovarian deficiency, then this deficiency does not necessarily demonstrate itself in the menstrual function.

Cheatle[2] believes that mazoplasia and cystiphorous hyperplasia are quite distinct conditions, and that mazoplasia is never a pre-cancerous condition, while cystiphorous hyperplasia is. Sampson Handley[3] believes that the two conditions are stages of the same process, which begins with lymph stasis and not infrequently ends in carcinoma. If these conditions are quite distinct, it seems difficult to account for a coincident increase in the incidence of nodularity and of cysts. So far these findings appear to agree with Sampson Handley's view. But the custom already referred to, of feeding a child at breast for 2 to 3 years, must surely be the most effective means of preventing lymph stasis, and these findings appear to show that lymph stasis is probably not the original ætiological condition. Further, Sampson Handley's view that the condition not infrequently ends in carcinoma is not supported. Smith and Elmes,[4] in an analysis of 500 cases of malignant disease in Nigeria, found 29 cases of carcinoma of the breast (3 of whom were males). In reviewing the literature on cancer in the African native, they show that the old view that cancer is more or less non-existent is no longer tenable. But it is very much rarer than in England. Their cases took 8 years to collect. In 15 months in Bida, I have seen one case of carcinoma of the breast. If chronic

mastitis in any of its forms is a pre-cancerous condition, then since the incidence of nodularity and cysts is much higher than in England, surely carcinoma of the breast should be a very much more common condition. Cheatle's view that 'mazoplasia' is not pre-cancerous certainly derives full support from these findings. But even the pre-cancerous nature of 'cystiphorous hyperplasia' is shown to be open to doubt.

SUMMARY

1. An examination of 140 African women showed 72 with nodularity of the breasts and 20 with cysts. These figures are twice as big as those reported in England.

2. No relation between nodularity and menstrual disorder was found.

3. In view of the marked frequency of chronic mastitis and the comparative rarity of carcinoma of the breast in the African, it is suggested that chronic mastitis is not pre-cancerous.

I am indebted to the Director of Medical Services, Nigeria, for permission to publish this paper.

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PULMONARY EMBOLISM

A STATISTICAL INVESTIGATION OF ITS INCIDENCE IN TWELVE LONDON HOSPITALS IN THE DECADE 1925-34

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INTRODUCTION

THIS investigation was undertaken primarily to determine whether pulmonary embolism has a seasonal or epidemic incidence. An impression that it had both had been formed during a general study of the condition at University College Hospital, and as this impression appeared to be shared by others it was thought desirable to settle the point by the collection and analysis of a large series of cases. The numerous hospitals within a small area in London should provide excellent material for such a study. The first approach to the problem was a request to the Registrar-General for the dates of death of all cases of fatal pulmonary embolism verified by post-mortem in London during the years 1929–34. The reply gave details of no more than 35 cases! As a single hospital could provide records of more cases than this it was clear that the records at Somerset House were useless for the purpose of the intended inquiry, and it was then decided to attempt the collection of cases from the London Teaching Hospitals. Permission to make use of their post-mortem records was generously granted by twelve hospitals; at eleven hospitals the actual records were examined by the author, the twelfth kindly provided the information required through its Surgical Registrar. Since the collection of the required data necessitated an actual perusal of the post-mortem records advantage was taken of the opportunity to collect information also on the following points when available; the morbid conditions associated with pulmonary embolism; the interval between trauma and death; the age and sex of patients; and the presumed site of primary thrombosis.

MATERIAL

The material for analysis comprises 731 cases of fatal pulmonary embolism occurring in the years 1925–1934 at 12 London Hospitals.* During this period 911,215 patients were admitted, there were 46,562 deaths, and 36,145 post-mortem examinations. The last figure includes cases brought into hospital dead, and therefore does not show the proportion of deaths in hospital investigated by post-mortem.

The contributions of individual hospitals to these totals are shown in *Table I*. In the last column the cases of pulmonary embolism are shown as a percentage of total admissions. The significance of the variation in this percentage between 0·050 and 0·142 cannot be assessed without more information than is available about the selection of patients, but there seems no doubt that it is in part accounted for

* At Hospital 10, records of post-mortem examinations were not available for 1925–26. The figures for this hospital are, therefore, for the years 1927–34 only.

by the variation in the proportion of deaths investigated by post-mortem. Had this proportion been uniform with the highest observed there would have been less variation in the incidence of pulmonary embolism, and the total of cases would have been larger.

Table I.—Incidence of Fatal Pulmonary Embolism Proved by Post-mortem at Twelve Hospitals in 1925–34 inclusive

Hospital	Total In-patients	Total Deaths	Post-mortems	Cases of Pulmonary Embolism	Percentage Incidence of Pulmonary Embolism in Total Admissions
1	148,058	7274	5645	208	0·142
2	110,538	5731	5405	65 (3)	0·056
3	48,808	2617	2643	34 (2)	0·065
4	71,527	4519	2863	65	0·091
5	54,887	1810	1635	30 (1)	0·053
6	73,017	3665	2781	57	0·078
7	49,938	2711	1925	25	0·050
8	96,278	5490	3428	54	0·056
9	111,986	5127	4573	81	0·073
10	37,794	1719	1309	32	0·085
11	66,682	3453	2345	51 (1)	0·075
12	41,702	2446	1593	29 (2)	0·065
Total	911,215	46,562	36,145	731 (9)	0·079

Notes.—The figures for Hospital 10 are for 1927–34 only. The post-mortems include cases brought in dead. The figures in brackets in Column 5 are cases brought in dead. These are excluded in calculating the percentages in Column 6.

A clinical diagnosis of pulmonary embolism is not always confirmed post-mortem, and when it is unsuspected embolism easily escapes observation unless it is systematically looked for in every case. For the purpose of this investigation, therefore, cases were only accepted if the post-mortem records gave a clear account of the embolism, and some were rejected in which the diagnosis appeared in index or heading but the notes made no mention of the embolus. This rigid selection excluded cases of small emboli not apparently contributing to the fatal issue.

For a statistical analysis of the time distribution of fatal pulmonary embolism this material is satisfactory if we assume that errors in diagnosis and records are evenly distributed. The other data that have been collected, however, such as age and sex incidence, cannot usefully be submitted to statistical analysis without the collection of related details which it has not seemed worth while to attempt. Hospital patients form a selected group, and the factors influencing their selection vary according to the nature of the hospital and the district in which it is situated. It might be supposed that some uniformity would be found at the London Teaching

Hospitals, but *Tables X* and *XVIII* suggest that this is not so. It is unfortunate that the records of most hospitals do not lend themselves to the rapid collection of data showing the initial selection of patients from the general population; the information collected for this paper has cost a surprising amount of trouble.

Since this study is only concerned with hospital patients, any conclusions which may be drawn are not necessarily applicable to pulmonary embolism in general. It is impossible to say how common this accident is outside hospital practice, but it is doubtless the cause of some of the sudden deaths attributed to other causes in the absence of autopsy by a competent pathologist. That its incidence is not confined to the obviously sick is shown by the " brought in dead " cases that figure in the hospital records.

FREQUENCY OF PULMONARY EMBOLISM

Because I am sure that the cases which I have collected do not show the true incidence of pulmonary embolism, I have made no attempt to calculate its frequency accurately either for the whole hospital population or for selected groups. Having regard, however, to the excess of deaths over post-mortems and the assumed incidence of undiagnosed or unconfirmed cases, I conclude that every year at least 100 patients die of pulmonary embolism at the twelve hospitals studied. Moreover, a perusal of the records of these cases suggests that more than half of this number might have been expected to survive many years but for this accident.

Table II.—Yearly Incidence of Fatal Pulmonary Embolism Proved by Post-mortem at Twelve Hospitals

Year	Total In-patients	Total Deaths	Total Post-mortems	Cases of Pulmonary Embolism	Percentage Incidence of Pulmonary Embolism in Total In-patients
1925	80,098	4524	3548	56 (1)	0·069
1926	81,640	4453	3428	61 (1)	0·073
1927	85,654	4768	3604	75	0·088
1928	86,922	4595	3727	67 (1)	0·076
1929	88,630	4735	3733	70	0·079
1930	93,804	4550	3624	64 (1)	0·067
1931	96,916	4956	3719	75 (2)	0·075
1932	98,223	4650	3523	83	0·085
1933	97,998	4689	3672	85	0·087
1934	101,330	4642	3567	95 (3)	0·090

Note.—The figures in brackets in Column 5 refer to cases brought in dead. These are excluded in calculating percentages in Column 6.

Table II shows the same data as *Table I*, arranged by years instead of hospitals. There is an increase during the decade of the number of cases of pulmonary

embolism. This increase corresponds with general experience, but does not lend support to the prevalent idea that the accident is actually becoming more common. In this series the increase is due to three factors. First there is an increase in the total admissions, secondly there is an increase in the proportion of surgical patients, and thirdly there is at some hospitals an increase in the proportion of deaths investigated by post-mortem examination. It is, moreover, a common observation that when interest is stimulated in a subject it attracts more attention, and an increase in the recorded incidence of a disease is to be expected in such circumstances. Column 6 of *Table II* shows the incidence of pulmonary embolism expressed as a percentage of total admissions, and the actual increase in the decade is very small.

TIME DISTRIBUTION OF CASES

The distribution of the 731 cases over the 3652 days of the decade was first studied and compared with the normal distribution found by calculating the Poisson series. The result is shown in *Table III*. The difference between observed and

Table III.—Daily Distribution of 731 Cases at Twelve Hospitals

Cases per Day	Expected Frequency	Cases	Observed Frequency	Cases
0	2989·51	0	2985	0
1	598·39	598·39	605	605
2	59·89	119·78	60	120
3	4·00	12·00	2	6
4	0·20	0·80	0	0
5	0·01	0·05	0	0
6	0·00	0·00	0	0
	3652·00	731·02	3652	731

expected frequencies is not significant. This single test makes it unlikely that there is any significant deviation from normal in the time distribution of the cases.

A similar study of the weekly distribution of the 208 cases at Hospital 1 was made. The results are shown in *Table IV*. Again the difference between observed and expected frequencies is not significant.

Table IV.—Weekly Distribution of 208 Cases at One Hospital

Cases per Week	Expected Frequency	Cases	Observed Frequency	Cases
0	349·508	0	351	0
1	139·534	139·534	137	137
2	27·853	55·606	28	56
3	3·707	11·121	5	15
4	0·348	1·392	0	0
	520·950	207·653	521	208

In *Table V* is shown the monthly distribution of the whole series for each year and for ten years summated. *Tables VI* and *VII* show the same data for the

traumatic and non-traumatic cases separately. In none of these tables is the variation in monthly incidence significant either for single years or for the ten years summated.

Table V.—Monthly Incidence of Pulmonary Embolism Proven by Post-mortem at Twelve Hospitals for Ten Years, 1925–34

Year	Total	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1925	56	7	3	5	8	1	5	3	2	3	5	8	6
1926	61	3	5	5	3	9	5	6	4	3	6	5	7
1927	75	4	6	7	8	4	5	10	6	8	8	2	7
1928	67	1	2	8	5	5	9	8	4	9	7	5	4
1929	70	7	4	5	3	5	4	5	7	4	11	6	9
1930	64	3	10	2	6	6	3	5	7	5	7	8	2
1931	75	6	8	5	6	5	4	7	8	7	1	10	8
1932	83	9	5	6	8	7	8	5	7	7	12	5	4
1933	85	5	5	11	10	5	8	4	7	7	8	9	6
1934	95	7	6	9	12	7	6	10	5	5	14	10	4
Total	731	52	54	63	69	54	57	63	57	58	79	68	57

Table VI.—Monthly Incidence—Traumatic Cases (Operations and Injuries)

Year	Total	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1925	44	6	2	5	7	1	3	3	1	1	4	6	5
1926	39	3	3	4	2	4	1	4	4	2	4	3	5
1927	61	2	5	6	7	4	4	6	5	7	6	2	7
1928	53	1	2	5	4	5	9	7	2	8	4	4	2
1929	62	6	3	5	3	5	3	4	6	4	9	6	8
1930	46	2	9	2	4	4	3	4	5	3	3	5	2
1931	59	5	6	5	5	5	4	5	5	5	1	7	6
1932	67	6	5	6	5	7	6	3	5	7	10	3	4
1933	69	3	3	9	7	4	8	4	6	6	5	9	5
1934	73	4	5	7	8	7	5	6	5	4	10	8	4
Total	573	38	43	54	52	46	46	46	44	47	56	53	48

Table VII.—Monthly Incidence—Non-Traumatic Cases

Year	Total	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1925	12	1	1	–	1	–	2	–	1	2	1	2	1
1926	22	–	2	1	1	5	4	2	–	1	2	2	2
1927	14	2	1	1	1	–	1	4	1	1	2	–	–
1928	14	–	–	3	1	–	–	1	2	1	3	1	2
1929	8	1	1	–	–	–	1	1	1	–	2	–	1
1930	18	1	1	–	2	2	–	1	2	2	4	3	–
1931	16	1	2	–	1	–	–	2	3	2	–	3	2
1932	16	3	–	–	3	–	2	2	2	–	2	2	–
1933	16	2	2	2	3	1	–	–	1	1	3	–	1
1934	22	3	1	2	4	–	1	4	–	1	4	2	–
Total	158	14	11	9	17	8	11	17	13	11	23	15	9

Significance was tested by calculating χ^2 and taking P = ·05 as the limit of significance. I have deliberately omitted details of the tests of significance, which can be found in Fisher's *Statistical Methods for Research Workers.*

The analysis of the time distribution of this series shows no evidence of seasonal or epidemic incidence. The validity of this conclusion rests on two assumptions: first, that the errors in diagnosis and records are evenly distributed; and secondly, that admission and selection of patients are uniform throughout the year.

MORBID CONDITIONS ASSOCIATED WITH PULMONARY EMBOLISM

The cases have been classified into traumatic and non-traumatic. Of the 731 cases, 537 followed operation, 36 followed accidental injuries, and in the remaining 158 there was no history of trauma. This predominance of traumatic cases is in accord with general experience and the common impression that pulmonary embolism is mainly a post-operative complication. In order to test the significance of trauma it is necessary to classify the total hospital patients into traumatic and non-traumatic groups. Unfortunately, this has not been possible, and the nearest practicable approach is the classification into medical and surgical. From eight of the twelve hospitals figures showing the relative numbers of medical and surgical patients in the decade were obtained; these are set out in *Table VIII.* The

Table VIII.—Total Medical and Surgical Patients, and Total Traumatic and Non-Traumatic Cases of Pulmonary Embolism, at Individual Hospitals for Ten Years

Hospital	Surgical Patients	Embolism after Trauma	Medical Patients	Embolism without Trauma
1	97,544	153	50,514	55
2	81,383	54	29,155	11
3	35,430	25	13,378	9
4	33,340	47	17,707	18
5		data not available		
6	50,950	44	20,371	13
7	29,303	23	15,468	2
8		data not available		
9	80,951	79	31,035	12
10	29,065	29	8,729	3
11		data not available		
12		data not available		

figures from three of these, however, do not correspond with the totals in *Table I.* From the figures for the remaining five the traumatic and non-traumatic embolisms were calculated as percentages of the surgical and medical admissions respectively. On this basis surgical admissions show an incidence of pulmonary embolism of 0·105 per cent, medical admissions 0·064 per cent (*Table IX*). Clearly this is a rough approximation only. An obvious source of error is that many surgical patients are discharged without operation and should therefore be classified as non-traumatic, while a certain number of medical patients are subjected to operation and should be classified as traumatic. To what extent these two errors

balance one another it is impossible to say. A further disadvantage is that no information is available about the selection of the two groups of patients. It seems clear, for instance, that pulmonary embolism has a definite age incidence, and any difference in the ages of medical and surgical patients would be reflected in the distribution of embolism in the two groups.

Table IX.—Approximate Estimate of Frequency of Pulmonary Embolism in Surgical and Medical Patients at Five Hospitals

Group	Total Admissions	Cases of Embolism	Percentage
Surgical	324,373	340 (traumatic)	0·105
Medical	132,811	85 (non-traumatic)	0·064

Because of these sources of error the above estimate of the frequency of pulmonary embolism in medical and surgical patients cannot be accepted without further investigation. It is quite clear, however, that the accident is not an uncommon cause of death in cases with no history of trauma. It is suggested, therefore, that the importance of trauma as a cause of pulmonary embolism has been exaggerated. Lister[1] has shown the predominance among operations followed by embolism of those necessitating an anterior abdominal incision, and explained it as due to the venous stasis following diminished respiratory movement. He noted, too, the high incidence of embolism in cases of fractured femur, which until the introduction of modern methods of treatment was, of common injuries, the one most likely to immobilize the patient. This association of embolism with injuries which immobilize the patient also appears in the series reported by McCartney,[2] and in the present series.

Table X shows the yearly fluctuations in the ratio of surgical to medical patients at the hospitals from which the data in *Tables VIII* and *IX* were obtained. It illustrates the variations in selection of patients referred to in the introduction.

Table X.—Values of $S/M = \frac{\text{Surgical Admissions}}{\text{Medical Admissions}}$

Year	Hospital											
	1	2	3	4	5	6	7	8	9	10	11	12
1925	1·3	3·0	2·4	2·4	–	1·6	1·3	–	2·6	2·6	–	–
1926	1·3	3·3	3·0	2·5	–	1·4	1·4	–	2·6	2·7	–	–
1927	1·6	3·1	2·8	2·5	–	1·4	1·5	–	2·5	2·8	–	–
1928	2·3	3·0	3·1	2·4	–	1·6	2·3	–	2·4	3·1	–	–
1929	2·4	2·6	2·5	2·5	–	1·6	2·3	–	2·4	3·0	–	–
1930	2·4	3·0	2·7	2·5	–	1·6	2·4	–	2·4	3·6	–	–
1931	2·3	2·7	2·5	2·5	–	1·3	2·4	–	2·5	3·4	–	–
1932	2·3	2·6	2·6	2·6	–	1·5	2·1	–	2·8	3·6	–	–
1933	2·2	2·4	2·3	2·6	–	1·5	2·0	–	2·8	3·3	–	–
1934	2·2	2·6	2·7	1·9	–	1·3	2·0	–	2·8	3·4	–	–

The frequency with which embolism occurs after the more common operations has been reported in many previous publications, and no attempt has been made to calculate percentage incidences in this series. It is well known that certain operations have a higher incidence than others, but the lesson of the present series seems to be that embolism may follow any operation, however trivial. Many, of course, of the trivial operations were performed on very ill patients, and their contribution to the fatal issue may be impossible to assess. One cannot assume, for instance, that the catheterization of a uræmic old man caused his death from embolism. It is to be expected, however, that the more ill a patient is before operation the more predisposed he will be to what appears to be the important factor in causing thrombosis, namely, immobility.

In *Table XI* are listed the diseases, operations, and injuries with which embolism was associated in the present series, and the number of cases recorded

Table XI.—Operations, Injuries, and Diseases Associated with 731 Cases of Pulmonary Embolism

A. Operations.—		
1. *General Abdominal Operations.*—		
Stomach and duodenum	50	
Bile-passages	37	
Appendicectomy (8 'cold')	54	
Laparotomy for various benign conditions	20	
Laparotomy for inoperable cancer	21	
Hernia, inguinal and femoral (8 strangulated)	18	
Hernia, ventral (1 strangulated)	13	
Cancer of colon and rectum, radical operations	11	
Colostomy (3 acute obstructions)	33	
Other palliative operations	7	
Benign conditions of rectum and anus	2	
Diverticulitis (2 colostomy)	6	
Ulcerative colitis	2	
	—	274
2. *Gynæcological.*—		
Abdominal operations (6 Cæsarean)	63	
Vaginal and vulval operations	23	
Puerperal (1 toxæmia)	7	
	—	93
3. *Genito-urinary.*—		
Suprapubic section	47	
Transurethral and perineal (3 catheterization)	9	
Renal operations	5	
Male external genitalia	4	
	—	65
4. *Operations on the Trunk.*—		
Thoracotomy	4	
Paracentesis (1 thorax, 1 abdomen)	2	
Dilatation of œsophagus	1	
Radical mastectomy	32	
Simple breast operations	2	
Radium for breast	5	
Radium for cancer of buttock	1	
Laminectomy	1	
Lipoma of back	1	
Inguinal gland dissection	1	
	—	50

5. *Operations on Head and Neck.*—		
Thyroidectomy	9	
Gland dissections	3	
Buccal cancer (4 radical operation, 1 radium)	5	
Alveolar abscess	1	
Quinsy	1	
Tracheotomy	1	
Rodent ulcer of face	1	
Myringotomy	1	
Injection of trigeminal nerve	1	
Operations on eye	4	
Cerebral operations (2 ventriculography)	4	
	—	31
6. *Operations on Limbs.*—		
For fractures of lower limb	5	
Ligature of femoral artery for aneurysm	1	
Amputations of lower limb (2 diabetic)	9	
Internal derangement of knee	1	
Varicose veins	2	
Excision of head of humerus	1	
Septic hand	1	
	—	20
7. *Nature of Operation not Recorded*	4	4
Total post-operative cases		537
B. INJURIES.—		
Fractures of lower limb and pelvis (neck of femur 13)	24	
Soft tissue injuries of lower limb	2	
Scalp wound	1	
Chest injury	1	
Hæmatoma of abdominal wall	1	
Concussion (1 fractured base)	2	
Multiple injuries	5	
	—	36
Total traumatic cases		573
C. CASES WITH NO HISTORY OF TRAUMA.—		
Idiopathic (no other gross disease unless peripheral thrombosis)	7	
Brought in dead (ditto)	9	
Cardiac disease	19	
Varicose veins	1	
Acute pneumonia	9	
Phthisis (1 with artificial pneumothorax)	8	
Bronchiectasis	1	
Diseases of central nervous system :—		
Cerebral	11	
Spinal	5	
Malignant disease :—		
Thoracic	8	
Abdominal	24	
Pelvic	8	
Head and neck	3	
Pregnancy	2	
Appendicitis	6	
Cholecystitis	1	
Peritonitis	1	
Intestinal obstruction	1	
Ulcerative colitis	5	
Piles	1	

Cystitis	2
Renal calculus	1
Pyelonephritis	1
Nephritis	1
Senile prostate	1
Prostatic abscess	1
Typhoid	2
Chicken-pox	1
Rheumatic fever	1
Blood diseases	3
Diabetes (1 with sepsis, 1 with gangrene) ..	7
Arthritis (2 chronic, 2 suppurative)	4
Toxic goitre	2
Myeloma	1
Total cases with no history of trauma..	158

in each category. In 16 of the non-traumatic cases no other disease was found except peripheral thrombosis, and that not in all. Nine of these were cases brought in dead; the others died in hospital and are classed as idiopathic. Reference has already been made to the probable occurrence of such cases outside hospital practice.

The group of cases following injury is of interest in that there is no example of injury to the upper limb. This may be due to the fact that such injuries rarely immobilize the patient, but for this very reason such patients are rarely admitted to hospital, and this study deals only with in-patients. Only three cases of varicose veins appear, two operated on, one not treated. No case of embolism following injection was found, although such are known to have occurred in hospital out-patients.

These examples are cited as a reminder that a selected sample of the population such as is dealt with in this study may give erroneous impressions of the frequency of embolism in certain conditions.

I owe to a personal communication from Sir Bernard Spilsbury certain observations on these points. He finds that the type of case which I have called idiopathic is not uncommon in coroners' post-mortems. In such cases it is usual to find thrombosis in varicose veins which may by extension to the deep veins have given rise to the embolism. He has, moreover, met with several cases of pulmonary embolism following the injection of varicose veins.

THE INTERVAL BETWEEN TRAUMA AND DEATH

In 440 of the 573 traumatic cases the interval between trauma and death was recorded. In *Table XII* is shown the distribution of these cases over intervals up to four weeks, cases occurring at longer intervals being grouped together. The incidence rises until the fifth day, remains fairly constant until the ninth, and then falls. Sixty cases occurred in the first four days after trauma, a period which is often regarded as safe. In some of these it is likely that peripheral thrombosis took place before the trauma. In 28 cases the interval was greater than four weeks, and in some of these trauma was probably an unimportant factor. In a few trauma was so remote that its significance is negligible except in so far as it affects the mobility of the patient.

Table XII.—Interval between Trauma and Death in Cases of Fatal Pulmonary Embolism

Days after Trauma	Cases	Days after Trauma	Cases
1	10	16	13
2	18	17	13
3	12	18	7
4	20	19	6
5	28	20	7
6	32	21	4
7	32	22	8
8	28	23	5
9	30	24	4
10	23	25	5
11	20	26	–
12	23	27	4
13	20	28	5
14	18	More than	
15	17	28	28

The wide variation in the interval between trauma and death makes it imperative that prophylactic measures, if of any value, should be employed over a long period. If immobilization is the important factor in ætiology, then clearly this should be the main indication for prophylaxis, not only in surgical but also in medical cases.

THE SITE OF PRIMARY THROMBOSIS

In 473 cases a record was found of a search having been made for the site of the primary thrombosis, and in 362 evidence of thrombosis in peripheral vessels was found. This evidence was usually the presence in the veins of massive thrombosis, sometimes the presence of fragments adherent to the intima of the vein. In the latter case the affected vein is probably the source of the embolus, in the former thrombus may have been detached from the proximal end of that found in the vein, or the embolus may have come from another vein leaving no trace of its origin. There are cases in which the size and shape of an embolus make a peripheral origin almost certain, and yet no evidence can be found of peripheral thrombosis. In 111 cases there is a record of failure to find evidence of the origin of the clot, and it is probable that many failures are unrecorded. Speculations as to the origin of the thrombus based on its size and shape have been disregarded. The fact that the thrombus can become detached, leaving no macroscopic trace of its origin, makes it difficult to determine the origin of the embolus even when peripheral thrombosis is found.

In *Table XIII* are recorded the sites at which evidence of peripheral thrombosis was found in 362 cases of all kinds, and *Table XIV* shows the same data for 92 cases with no history of trauma. For the reasons given above, the data in these tables are not to be regarded as a complete indication of the source of emboli. There are, however, some points about the distribution of thrombosis which may

be significant. In the non-traumatic cases the incidence in the leg veins of the two sides is about equal, but in the traumatic cases the right side is more commonly affected than the left. More detailed analysis suggests that there may be a relationship between the site of trauma and thrombosis. In *Table XV* is shown the incidence of thrombosis on the two sides after certain operations and injuries, and it appears that after right-sided operations and injuries the incidence of right-sided thrombosis is higher than in the whole series. This is somewhat surprising in view of the observation that femoral thrombosis diagnosed during life is commoner on the left than the right, and no association between the site of operation and thrombosis is apparent. It is unfortunate that the information available in the post-mortem records was not adequate for a more complete investigation of this point. The cases in *Table XV* form but a small fraction of the total.

Table XIII.—Sites of Peripheral Thrombosis in Cases of Fatal Pulmonary Embolism

Affected Veins	Number of Cases
Right common iliac, right external iliac and tributaries	139
Left common iliac, left external iliac and tributaries	103
Both common iliacs, both external iliacs and tributaries	49
Right internal iliac and tributaries	22
Left internal iliac and tributaries	27
Both internal iliacs and tributaries	8
Pelvic plexuses	9
Inferior vena cava	10
Renal	2
Intercostal	1
Epigastric	1
Cerebral sinus	1
Axillary	3
Subclavian	1
Innominate	2

Notes.—In 3 of the above cases thrombus was found in two sets of veins not directly connected. In 6 cases thrombus in the heart was recorded as the source of embolus, and in 1 case a subcutaneous nævus.

Table XIV.—Sites of Peripheral Thrombosis in Cases of Fatal Pulmonary Embolism without History of Trauma

Affected Veins	Number of Cases
Right common iliac, right external iliac and tributaries	33
Left common iliac, left external iliac and tributaries	32
Both common iliacs and tributaries	14
Right internal iliac and tributaries	3
Left internal iliac and tributaries	5
Pelvic plexuses	2

Note.—In 5 cases in this group thrombus in the heart was recorded as the source of the embolus.

Table XV.—Association between Site of Peripheral Thrombosis and Certain Operations and Injuries

Operation or Injury	Site of Thrombosis	
	Right Lower Limb	Left Lower Limb
	Cases	Cases
Cholecystectomy	13	4
Appendicectomy	19	9
Right radical mastectomy	3	2
Injury to right leg	7	2
Left radical mastectomy	2	3
Injury to left leg	3	5
Operations on head and neck	5	2
Total right-sided operations and injuries ..	42	17
Total left-sided operations and injuries ..	5	8

AGE AND SEX INCIDENCE

Age.—The age incidence of the whole series and of the traumatic and non-traumatic cases separately is shown in *Table XVI.* The maximum incidence of actual cases falls in the five years 55–59. I have been unable to collect information about the age distribution of the hospital population from which the series is taken. It appears clear, however, that the number of children admitted to the hospitals varies, and where the proportion of children to adults is high there will be a lower incidence of embolism. I think it is probable that a part of the variation in the incidence of embolism at the twelve hospitals can be attributed to this factor.

Table XVI.—Age Distribution of 731 Cases of Fatal Pulmonary Embolism

Age in Years	Number of Cases		Total
	Traumatic	Non-traumatic	
0–4	1	1	2
5–9	0	1	1
10–14	0	1	1
15–19	3	1	4
20–24	4	1	5
25–29	10	3	13
30–34	13	7	20
35–39	33	10	43
40–44	38	9	47
45–49	66	20	86
50–54	79	19	98
55–59	99	28	127
60–64	86	18	104
65–69	67	22	89
70–74	41	6	47
75–79	15	3	18
80–84	7	0	7
85–89	3	0	3
Not recorded	8	8	16

Sex.—The sex distribution of the cases is shown in *Table XVII.* The distribution for certain groups is also shown. I have not been able to collect sufficient data to determine whether the female sex is actually more prone to embolism than the male. Such information as was available about the sex distribution of patients is shown in *Table XVIII.* In the non-traumatic cases in this series the sex distribution is about equal, whereas in the traumatic cases there is a preponderance of females. In the small group of injuries the sex difference is accounted for by fractures of the neck of the femur. The figures in *Table XI* shows that a large number of the cases in this series have followed operations for conditions proper to or more common in the female sex.

Table XVII.—Sex Distribution of Fatal Pulmonary Embolism

Group	Males	Females
Whole series	287	433
Traumatic cases	216	356
Non-traumatic cases	81	77
Fractures	12	27
Fractures of neck of femur	1	12
Appendicitis	21	33
Cholecystectomy	5	30
Operations on stomach and duodenum ..	35	11

Table XVIII.—Sex Distribution of Total Admissions at Individual Hospitals during Ten Years

Hospital	Surgical		Medical	
	Males	Females	Males	Females
1	45,389	52,155	26,387	24,127
6	17,844	19,507	10,786	9,585
7	Figures not available		6,942	8,526
8	16,418	16,204	9,136	7,918
9	37,058	43,897	13,569	17,466

SUMMARY

A series of 731 cases of fatal pulmonary embolism during the years 1925–34 has been collected from twelve London Hospitals. Diagnosis was proved in every case by post-mortem examination.

It is suggested that during the decade studied a considerable number of cases has escaped diagnosis, and that the incidence of pulmonary embolism is higher than is generally recognized.

No evidence has been found to support the impression that pulmonary embolism has any seasonal or epidemic incidence.

In 573 cases there was a history of trauma, in 158 there was none.

The predominance of traumatic cases is partly due to the high proportion of surgical patients admitted to the hospitals.

A rough approximation shows an incidence of 0·105 per cent in surgical cases, and 0·064 per cent in medical cases.

It is suggested that a more important factor in ætiology than the nature of the illness or trauma is immobilization of the patient.

In traumatic cases the interval between trauma and death varies from one day to many weeks.

The supposed primary thrombosis was found in the veins of the right leg more commonly than the left in traumatic cases.

There appears to be an association between right-sided injuries or operations and thrombosis in the veins of the right leg. This has not been observed, however, in cases of post-operative thrombosis not followed by fatal embolism.

The age incidence reaches a maximum in the five years 55–59, both for traumatic and non-traumatic cases.

In the non-traumatic cases there are equal numbers of males and females. In the traumatic cases females are in the majority. It has not been possible to estimate the true sex or age incidence owing to lack of information about the sex and age of the hospital population.

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FIBROMA OF THE KIDNEY WITH CYST

By H. J. NIGHTINGALE
SENIOR SURGEON TO THE ROYAL SOUTH HANTS AND SOUTHAMPTON HOSPITAL
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THE marked infrequency of large fibromata of the kidney would appear to justify the recording of the following case.

CASE HISTORY.—G. H., a man of 41 years of age, was referred to the out-patient department for investigation about a right-sided abdominal tumour. The patient complained of not being quite fit for a year, and for three months had suffered from 'rheumatism' around his ribs. He had felt some slight discomfort in the right side of the abdomen for three weeks, and had noticed a swelling in his abdomen while having a bath.

CLINICAL EXAMINATION.—A tense regular swelling the size and shape of a rugby football occupied the right half of the abdomen. It extended from the right costal margin above to immediately above the right inguinal ligament below, and extended for an inch across the midline in the region of the umbilicus. The swelling moved on respiration, and dullness over it was continuous with the liver dullness. Bimanual examination was not definite in determining whether the tumour was renal in origin. It was thought that the swelling might be a tense cyst, possibly in association with the kidney.

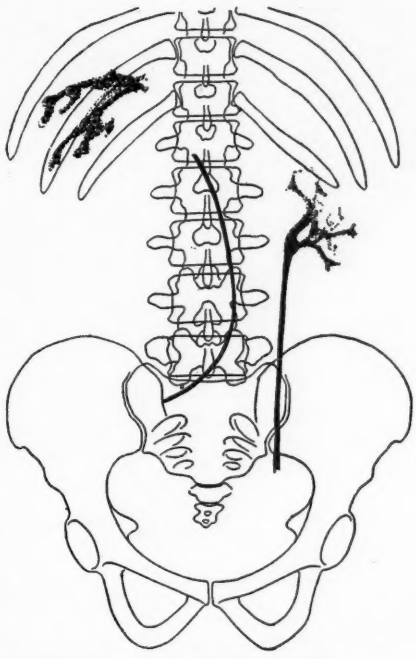

FIG. 31.—The pyelogram shows a normal appearance on the left side. On the right side the ureter in its abdominal and upper pelvic portions is markedly displaced towards the other side. The pelvis and calices are somewhat distorted and elongated, and the entire kidney is displaced upwards and rotated.

CYSTOSCOPY AND PYELOGRAPHY.—These were carried out on Sept. 28, 1936, to confirm or refute the renal origin of the tumour. The bladder was normal on cystoscopy, and a clear efflux was observed from either side. The left pyelogram was normal. The opaque catheter on the right side was displaced across the midline from the region of the first sacral to the level of the second lumbar vertebra, and at the level of the first lumbar vertebra the upper end of the catheter lay in front of the right side of the vertebral body. The pyelogram here showed that the kidney was displaced upwards and rotated, with the major and minor calices pointing downwards, and downwards and outwards. The pelvis lay above transversely, showing a rotation of the kidney in a counter-clockwise direction through an angle of 90°. Some lengthening and distortion of the calices were present. The displacement of the

opaque catheter and the rotation of the kidney seemed to be caused by a large renal or juxta-renal tumour which obscured the psoas shadow on the right side, but which otherwise was not visualized on X-ray examination. A pyelographic diagnosis of a large solitary cyst of the kidney was made (*Fig.* 31).

OPERATION.—On Oct. 5 the tumour was explored by a long lumbar incision, and a very large cystic swelling arising from the right kidney was found to be present. This was separated with comparative ease from the peritoneum and the surrounding structures, but it was found necessary to aspirate the cyst before its delivery could be effected. A pint of greenish-yellow fluid containing cholesterol crystals was drained, making the subsequent delivery easy. The ureter was ligated and divided near the pelvic brim, and after the pedicle had been isolated and ligated the mass was removed. The wound was sutured, with drainage.

FIG. 32.—The replacement of a large part of the kidney by the fibroma and its typical 'watered silk' appearance on section are well shown. The remnant of the cyst wall can be seen on the left side of the picture, and remaining renal tissue at the top and bottom. The section through the tumour has been in the coronal plane, and the displacement of the kidney causing the ureter to spring from the upper pole of the tumour is seen.

Convalescence was normal, the patient returning home on Oct. 24.

Examination of the tumour after removal showed that it consisted of a large cyst measuring $10 \times 7 \times 5$ in. At the upper pole of the cyst was the rotated kidney, which had been mainly replaced by a fibroma.

PATHOLOGICAL REPORT.—"The specimen consists of a tumour with a remnant of kidney tissue (*Fig.* 32). The upper and lower poles and pelvis are present, but the remainder of the organ is replaced by a tumour measuring 5 in. long by $4\frac{1}{2}$ in. wide and $2\frac{1}{2}$ in. deep. The tumour and kidney weighed 24 oz. At the opposite side of the kidney there is a large cyst (opened at operation). The tumour is lobulated, hard in consistency, and the cut surface has the typical 'watered silk' appearance of a fibroma.

"The histological appearance of the solid tumour is that of a fibroma (*Fig.* 33). Interlacing strands of fibroblasts and connective tissue are seen running in all directions. By van Gieson's stain no smooth muscle can be found. There is slight lymphocytic infiltration around some of the blood-vessels.

There are no areas of degeneration. The tumour cells are abundant and closely set, but the nuclei show no mitoses and the appearance does not suggest a sarcoma.

" Several different areas of the cyst wall have been examined. They show a dense fibrous-tissue capsule and the cyst lining composed of granulation tissue containing numerous fat-laden phagocytes and numerous kidney tubules, which form a layer all around the cyst. The tubules are ill formed, collapsed, or cystic. The cyst wall shows the remains of kidney tissue throughout."

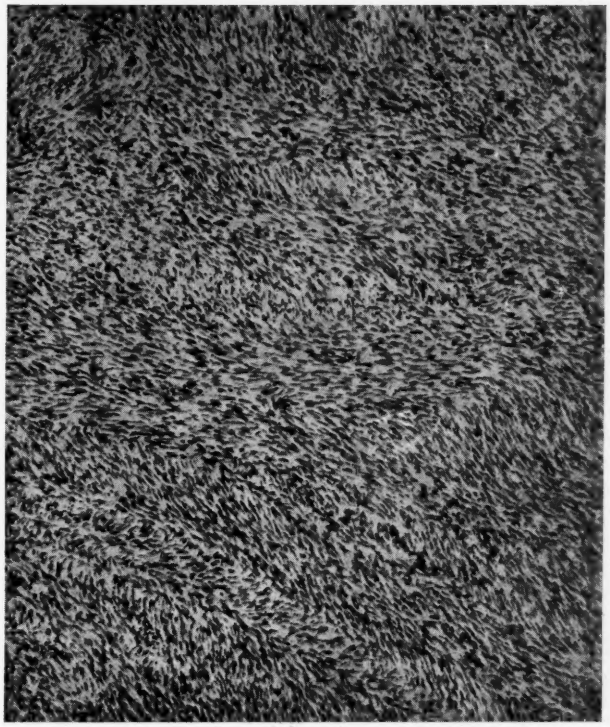

FIG. 33.—Microphotograph of a section of the fibroma. The interlacing strands of fibroblasts and connective tissue running in all directions are shown. (× 60.)

Commentary.—The points of interest in this case are the nature of the tumour and the relation of the cyst to the tumour. The cyst has probably been produced by obstruction and continued secretion of the tubules in the thinned-out renal tissue forming part of the tumour capsule. Cholesterol is common, of course, in all types of kidney cysts, and is probably formed from breakdown of red cells and tissues.

Alternative suggestions, which may be discarded, are :—

1. That the specimen shows a coexistent fibroma and a solitary cyst. Against this is the fact that the cyst almost surrounds the tumour. Moreover, solitary cysts do not have thinned-out kidney tissue in the wall.[1]

2. That the specimen is an embryoma (Wilms' tumour) with a one-sided development of fibromatous tissue. Geschickter[2] states that one-third of all Wilms' tumours are composed of spindle cell and tubule tissue. However, in this

case the tubules appear to be a relic of normal kidney tissue and not part of the growth, as they are only found in the internal layer of the cyst wall.

It would appear, therefore, that the condition was a simple fibroma growing from renal tissue, and that by its growth away from the pelvis it caused but slight distortion of the pelvis and calices. The cyst has possibly been a late development, and by its comparatively rapid formation may have caused the recent slight symptoms of which the patient complained.

Reported cases of renal fibromata in the literature are very few. Marion[3] states in a recent text-book on urology, " Les fibromes du rein sont absolument exceptionelles à l'état pur, si tant est qu'ils existent ". However, some large fibromata have been recorded. In Bruntzell's[4] case the fibroma weighed 20 lb., and Morris[5] mentions a case in which the kidney was replaced by a fibroma as large as a child's head, consisting of very hard translucent fibrous tissue. Gordon-Taylor[6] records a case of an adeno-fibroma weighing 22 lb. which was successfully removed by operation from a female aged 20 years. In this case the microscopical appearances showed numerous tubules lined by cubical or rounded cells. The tumour is described as being the largest benign tumour of the kidney on record, but in a case reported in Hektoen and Riesman's *Text-book of Pathology* (1902, ii, 980) a fibroma of the kidney weighed 37½ lb.[7] Other cases of fibromata are mentioned by Steinle[8] and by Boross.[9] Counseller and Menville[10] report a case somewhat similar to our own in which a leiomyoma was accompanied by a cyst containing cholesterol.

We are indebted to Dr. Gleave for his pathological report, and to Professor T. B. Davie for the microphotograph.

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SCLERODERMA SIMULATING CARCINOMA OF THE BREAST

By MARK COLEMAN
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Two cases are here described of the localized type of scleroderma affecting the skin of the breast. Both resembled malignant disease so strongly that operation was resorted to; in one case exploratory incision and excision of the affected area, and in the other a local biopsy, being performed. They derive their importance, therefore, not only from the difficulty which they presented in diagnosis, but also from the patients' point of view in respect of prognosis. The incidence of the disease may be stated as not uncommon, but it must be rare to meet two cases in ordinary surgical practice within eighteen months; and although the diagnosis might have been obvious clinically to the dermatologist, yet in both cases the practitioner and surgeon were suspicious of carcinoma and the diagnosis was proven only by microscopic examination.

CASE REPORTS

Case 1.—Mrs. F. G., aged 32 years, a housewife, complained of the painless development of a lump and distortion in the right breast during the past five months. She states that she noticed accidentally a swelling "like a finger" in the skin below the nipple and gradually

FIG. 34.—*Case* 1. The right breast, showing the area of scleroderma below the areola.

the breast had become depressed in this region. She was a multipara and had suckled her last infant 2½ years previously; there was no history of breast or skin sepsis or trauma, and she had always been healthy.

Examination showed a healthy-looking, fairly well-covered woman, afebrile and with normal pulse-rate. The right breast was smaller than the left, but the nipple was symmetrically disposed and equal in size to that on the opposite side. Below the right areola was a

transverse furrow about four inches long, its base depressed about half an inch below the surrounding skin. The skin in and around this furrow was shiny, showed faint purplish discoloration, and looked œdematous. The patent mouths of enlarged sweat glands were obvious, whilst on palpation the affected skin was thickened, indurated, and inextensible. The surface of the skin was smooth and the limits of the change ill defined, but tended to be outlined by telangiectasis. With the flat of the hand no mass could be palpated in the breast tissue, but the changed skin felt quite solid when picked up between the fingers, and careful palpation was necessary to convince me of the absence of a tumour. *Fig.* 34 shows clearly the depressed area, the delicate lines at the inner corner of the furrow, and the dotted depressed points resembling the patulous orifices of sebaceous glands. There was no evidence of general endocrine disturbance. A single small soft mobile gland was palpable on the inner wall of the right axilla.

Biopsy revealed the true nature of the condition (*see Fig.* 35).

After twelve months of massage, re-examination shows that the lesion is unaltered in size, rather more atrophic in appearance, and a little more supple.

Case 2.—Mrs. A. L., aged 40 years, a housewife, complained of ill-defined pricking sensations in the right breast and that the breast "felt different". She had suckled four children, the youngest fourteen years previously. A boil in the right axilla had needed incision some twelve months ago, but prior to this there was no relevant history of sepsis or trauma.

The patient was obese and the breasts pendulous. There was a little tenderness in the lower outer quadrant and the skin here felt firmer than the surrounding integument. No abnormality was noticed or mass palpated, and the case was dismissed.

Twlve months later she presented a lesion very similar to the last case. The skin over the affected quadrant was now retracted and discoloured, a sector-shaped area being involved. It was smooth and shiny and dry, with patchy violaceous discoloration and irregular small pittings over its surface. Its limits were well defined, and again the skin was hard and inextensible and no underlying mass could be palpated. The nipple and areola were normal.

One's first impression before examination was the almost certain expectation of being able to palpate a tumour, and, as in *Case* 1, the failure to do so led to an exploratory operation. The affected portion of skin and underlying fat was excised. Unfortunately there were no facilities for photography before treatment was commenced.

HISTOLOGY

Illustrations show identical histological pictures in both cases (*Figs.* 35, 36). There is marked hypertrophy of the collagenous tissues throughout the corium,

FIG. 35.—*Case* 1. Microscopic section of biopsy specimen.

forming a well-defined band which extends up to the epidermis. The latter is diminished in thickness, and there is flattening of the normal wavy line caused by

alternating rete pegs and papillæ. For the most part this change is acellular, but collections of lymphocytes surround a few dilated blood-vessels. The sweat glands and ducts are diminished in number and appear compressed by the collagenous

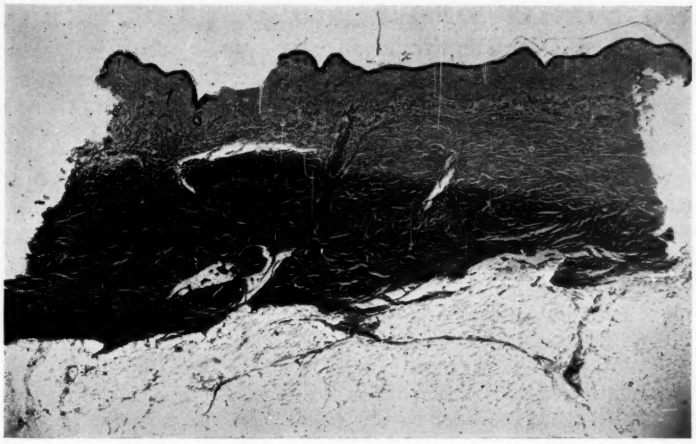

FIG. 36 —*Case* 2 Microscopic section of excised skin.

tissue. Staining for elastin showed that this was normal in amount but considerably fragmented by the presence of the collagenous bundles. These changes are all characteristic features of ordinary scleroderma.

DIAGNOSIS

Unlike the generalized type, circumscribed scleroderma is not accompanied by general symptoms or vasomotor phenomena, and there are usually no associated subjective symptoms. The fully developed lesion, particularly if multiple, may be readily diagnosed. Its characteristics are stated as being an ivory or silvery pigmented patch with a violaceous halo. The cases mentioned have apparently not yet progressed to this atrophic stage.

The surgeon is concerned principally with the differentiation from cancer in the possible forms of changes in the skin overlying a growth, or cancer *en cuirasse* in a primary case, or around the scar following mastectomy. The skin changes in scleroderma are localized and well defined; distinct nodules in the skin are never present; and no mass can be palpated in the breast.

No age is exempt from scleroderma, but adults are more often affected, and more than three-quarters of the described cases have been in females, mostly between the ages of 21 and 40 years.

Whilst the differentiation from cancer remains in doubt, however, it would appear advisable to resort to biopsy.

SUMMARY

1. Two cases of localized scleroderma resembling carcinoma of the breast are described.

2. A short account of the histological appearances is given, and a few notes concerning diagnosis.

I am indebted to Mr. Julian Taylor for permission to record *Case* 1.

A HITHERTO UNDESCRIBED FRACTURE OF THE PATELLA

By D. M. MEEKISON, Vancouver, Canada

CASE REPORTS

Case 1.—In May, 1935, there presented himself for treatment a logger, P. M., aged 34, who stated that two weeks previously a log had rolled down from a flat car and had jammed his leg against a stump. He suffered a fairly severe injury of his left knee and was removed to a local hospital. On examination there was found to be a loss of the whole thickness of skin over an area 3 by 2 in. on the antero-lateral aspect of the left thigh just above the level of the patella. The knee-joint was moderately filled with fluid, but no accurate diagnosis could be made of any internal derangement.

At the end of two weeks he came under the author's care. At this time the leg was found to be œdematous from the knee to the groin. Extension of the knee was impossible, and flexion was limited at less than a right angle. There was a large dry area of slough just above the patella level on the antero-lateral aspect of the thigh. The whole knee-joint level was firmly indurated. X-ray examination in all possible views was negative. The only diagnosis that could be made was, apart from gouging laceration, probably an internal derangement of the knee-jont. Forty-eight hours' rest and heat vastly improved the situation. The lacerated area began to show a nicely granulating base and the general reaction subsided. Soon it was possible to do a Reverdin graft which took successfully.

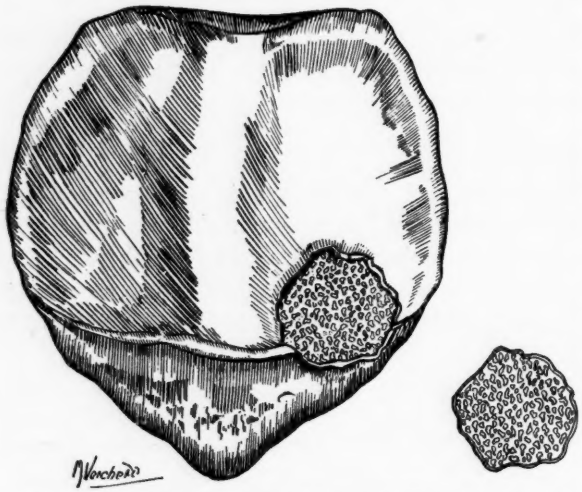

FIG. 37.—Showing the patella with a patch of bare bone on the articular surface, and the separated fragment.

Later, when it was possible adequately to examine the knee, the impression of an internal derangement of the knee-joint was further confirmed, but the picture seemed confused. The most striking sign was the sensation of something palpable, loose, and decidedly tender in the lateral joint, one inch lateral to the patella. In addition to this, extension was limited by pain, and signs were present of an injury to the internal semilunar fibro-cartilage, although there was no pain on external rotation of the flexed tibia on the femur. It was decided to explore the knee-joint.

At operation there was found a posterior tear of the internal semilunar cartilage, and in the lateral pouch there was found a portion of the patella the size of a twenty-five cent piece, which, after searching, matched perfectly an area of bare bone on the articular surface of the patella at its medial and inferior corner (*Fig.* 37).

Convalescence was rather prolonged, with considerable wasting of the quadriceps and vasti. Ultimately the man returned to industry, but when recently seen with a fresh injury, this time of the chest, the left leg was still slightly smaller than the right and there was a little 'rubbing' of the patella when relaxed, although the patient had no complaint to make.

Case 2.—P. W. E., male, aged 23. First seen in July, 1935. He, too, was a logger. Nearly two months previously he was lifting a log, taking one end. His mate at the other end slipped and the patient had to take all the weight. As his end of the log settled rather rapidly to the ground, his left knee, in flexion, collapsed in abduction and struck its antero-medial aspect against the log. He states that he had to " push his knee into joint " himself. His local attendant had his knee immobilized, to no avail.

When he was sent in to the writer, the patella was found to be extremely mobile, the internal lateral ligament was acutely tender at its upper attachment, there was a little fluid in the joint, and a tender thickening in the lateral pouch of the knee. X-ray examination was negative. After preliminary heat and rest with improvement, the author too immobilized the knee. Conservative treatment for six months produced no improvement. It was then decided to open the knee-joint.

At operation a loose tag of internal semilunar cartilage was found protruding into the joint from the anterior end of that member, and firmly adherent to the lateral condyle of the femur a piece of bone—more or less circular in shape—measuring 2 cm. in each direction, which corresponded exactly to a raw area on the articular surface of the patella at its inferior and medial corner (practically the same as shown in *Fig.* 37). The tag and fragment were removed. The internal semilunar cartilage seemed to be otherwise intact.

Convalescence was decidedly prolonged, and gross atrophy of the thigh and calf persisted, although recently the leg seems to be getting larger and power seems to be increasing. There is still decided ' rubbing ' of the patella when it is relaxed. A week before this was written he was considered fit for light work and given an award by the Compensation Board.

Case 3.—R. T., female, aged 26; almost totally blind. In September, 1935, she was proceeding down the stairs of her apartment when she slipped. Her left knee was twisted in abduction and her patella struck a glancing blow against the bannister post. She states that the patella was knocked sideways and she pushed it back. By the following day pain had greatly increased, the joint was badly swollen, and she decided that medical attention was indicated. There was found a joint greatly distended, presumably with blood, and pain on almost any movement. She was sent into hospital, where about 30 c.c. of blood was aspirated from the joint. After preliminary heat and rest the diagnosis of fracture of the articular surface of the patella was made, based on a mobile tender mass in the lateral pouch of the joint. X-ray examination in all possible views, including ' skyline ', was negative.

The joint was opened by the parapatellar route and a fragment of patella measuring 1·5 cm. each way and almost circular in shape was found lying in the lateral pouch of the joint. It was obviously torn out from a raw area on the articular surface of the patella at its medial and inferior aspect (again as in *Fig.* 37). A rent in the medial expansion of the quadriceps was repaired. The fibrocartilage seemed to be intact.

Convalescence here was prolonged, with considerable atrophy of the extensor apparatus. In six months she was quite able to carry on her household duties, although she complained of weakness in the knee to some degree, and the patella still ' rubs ' in the relaxed position.

SUMMARY

1. A hitherto undescribed fracture of the patella is reported.

2. The mechanism seems to be a rather severe injury, in the main consisting of a glancing blow on the patella from the inner side and directed obliquely posteriorly, whereby the inferior and medial corner of the articular surface is knocked out, presumably by the lateral condyle of the femur.

3. The loose fragment is always found in the lateral pouch, can be palpated, and is tender.

4. X-ray examination, with present technique, does not reveal this fracture.

5. Convalescence is always prolonged, with the prospect of some slight permanent disability.

6. The only treatment so far seems to be arthrotomy, repair of the quadriceps expansion, inspection of the fibrocartilages, and removal of the fragment.

PRIMARY SOLITARY DIVERTICULITIS OF THE CÆCUM
A REPORT ON 3 CASES, WITH A REVIEW OF 17 RECORDED CASES

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WITHIN a few months three cases of diverticulitis of the cæcum occurred in the practice of surgeons who were associated with the Liverpool Royal Infirmary: only 17 previously recorded cases can be found in accessible literature, so I venture to add accounts of the three cases mentioned above.

CASE REPORTS

Case 1.—Female, aged 21, single, admitted to the Bootle General Hospital on May 29, 1936, as a case of acute appendicitis.

HISTORY.—She had suffered from attacks of lower abdominal pain and vomiting while at school about 8 years previously. The attacks had become more frequent lately and had often settled in the right iliac fossa. The present attack of 24 hours' duration was associated with vomiting.

ON EXAMINATION.—Normal appearance except slightly flushed. Tongue dry and furred. Temperature 99° F. Pulse 80. Restricted abdominal movement on respiration. Tenderness and rigidity in the right iliac fossa rather close to the midline; rectal examination was negative.

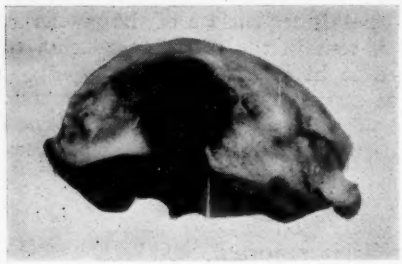

FIG. 38.—*Case* 1. Photograph of diverticulum and its concretion bisected. (*Natural size.*)

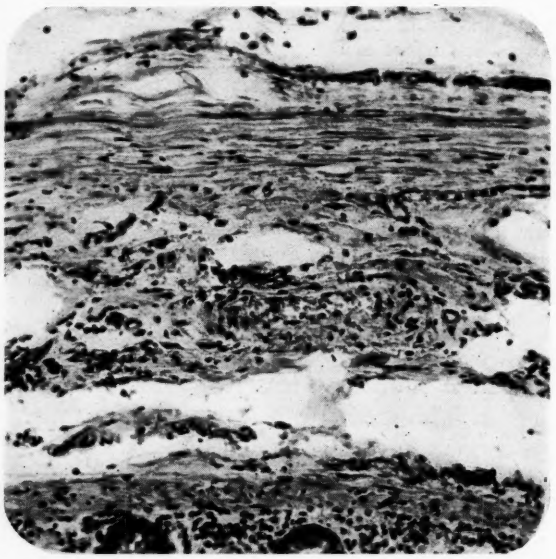

FIG. 39.—*Case* 1. Microphotograph of coronal section of diverticulum. (× 140.)

The urine and chest revealed no abnormality.

OPERATION. — Gridiron incision under ether anæsthesia. The appendix was removed and found to be normal. A hard mass about 1½ in. in diameter was present on the anterior cæcal wall; it was about ¾ in. thick. A tiny nodule was palpable on the mucous membrane, which I regarded as submucous tuberculosis instead of the protruding portion of the concretion. After applying light intestinal clamps the affected area of the cæcum was excised. The hole in the cæcum was closed with a Connell and then a

Cushing suture. The abdomen was closed without drainage. The patient had a normal convalescence. On the 18th day she was given a barium enema, but there was no evidence of diverticulosis.

EXAMINATION OF SPECIMEN.—The excised portion of the cæcum was grossly thickened, due to an oval diverticulum 1½ cm. long and 1¼ cm. wide, containing a fæcal concretion (*Fig.* 38). Part of the concretion was protruding into the lumen of the bowel through the narrow neck. The surrounding cæcum was thickened and congested, but there was no pus formation or peritonitis visible.

HISTOLOGY.—Sections were prepared from the whole length of the coronal section of the diverticulum by Dr. T. Hewer, in the Pathological Department of the University of Liverpool. They were stained with van Gieson's stain as well as with hæmatoxylin and eosin in order to define the muscular layer. They showed that the mucous membrane was ulcerated near the neck of the diverticulum, and that there was polymorphonuclear infiltration, most marked in the submucous tissue but extending right through the muscular coat to the subserous tissue. The muscular coat was apparently in two layers. (*Fig.* 39.)

Case 2.—Female, aged 28, single, admitted into a Nursing Home in Wallasey as a case of acute appendicitis.

HISTORY.—She had previously suffered from attacks which were regarded as due to migraine, but before the present attack she had no abdominal pain. The present attack started 24 hours before admission, as a dull lower abdominal pain which gradually increased in severity and settled in the right iliac fossa. There was no vomiting.

ON EXAMINATION.—Otherwise healthy patient with a dry tongue. Temperature 99° F. Tenderness and rigidity were found in the right iliac fossa on examination of the abdomen.

OPERATION (Mr. Robert Kennon, June 28, 1936).—Gridiron incision. A small quantity of fluid was present in the peritoneal cavity. The appendix was slightly congested externally and was therefore removed. On the antero-internal aspect of the cæcum just above the ileo-cæcal valve a congested infiltrated area was found, extending into the mesentery. On palpation of the mucous membrane the mouth of the diverticulum was recognized. The affected area of the cæcum was excised and the hole sutured in two layers. The wound was closed with drainage down to the site of the excised diverticulum.

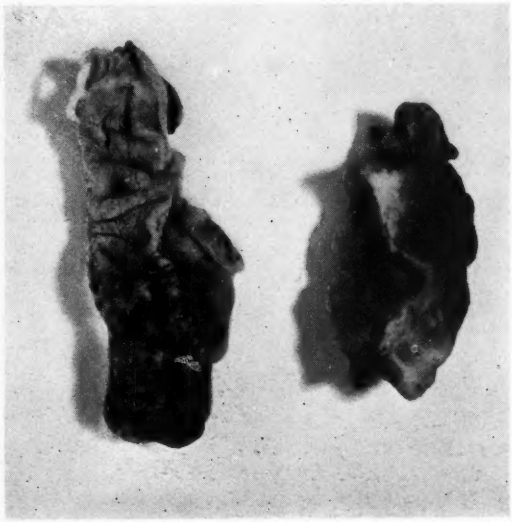

FIG. 40.—*Case* 2. Photograph showing concurrent inflammation in the cæcal diverticulum and in the appendix. (*Natural size.*)

POST-OPERATIVE COURSE.—A little fæces discharged on the fourth day, with purulent discharge on the seventh. Recovery was then uneventful. Her own doctor reports that there is still a little pain in the side, but he thinks it is gradually disappearing.

EXAMINATION OF SPECIMEN.—The specimen consists of a shallow diverticulum with a wider mouth than that of other recorded cases. The surrounding cæcum is very thickened and congested, and contains a small calcified area. No concretion was present. The distal half of the appendix had a congested mucous membrane and contained a concretion. (*Fig.* 40.)

HISTOLOGY.—Sections were made under the direction of Dr. Howel Evans, and were stained by van Gieson's stain as well as by hæmatoxylin and eosin. They showed an intense acute inflammatory change starting in the mucous membrane, which was ulcerated in places. Very marked œdema and extravasation of blood were present. No muscle can be seen in the low-power view, but a few fragmented muscle bundles can be seen in the high-power view at the sides of the diverticulum. (*Figs.* 41, 42.) There is therefore definite evidence that the

muscular coat is interrupted, and that this 'false diverticulum' might have been caused by the healing of a small tuberculous focus producing a calcified nodule.

FIG. 41.—*Case* 2. Microphotograph showing marked inflammatory changes with œdema and extravasation of blood. The mucous membrane is partially ulcerated. No muscle is easily recognizable. (× 15.)

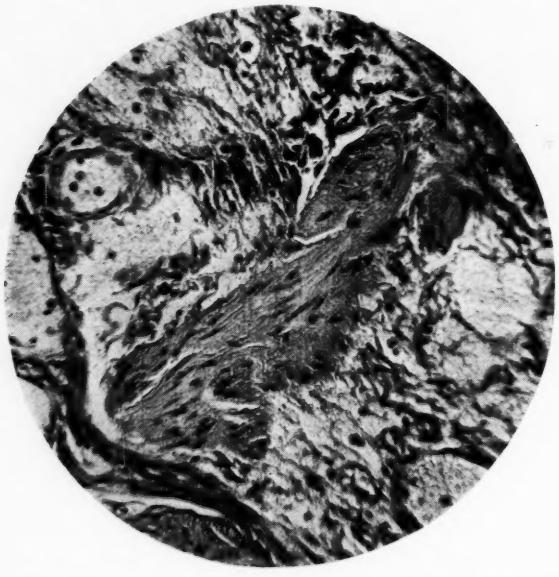

FIG. 42.—*Case* 2. Microphotograph showing a few fragmented muscle bundles. Leucocytic infiltration, œdema, and extravasation of blood-corpuscles are also visible. (× 200.)

Case 3.—Male, aged 26, admitted to the Liverpool Royal Infirmary as a case of acute appendicitis, under Mr. Nuttall.

HISTORY.—He had only previously suffered from constipation. His pain started 60 hours before admission as a general diffuse pain without any definite colic. It later settled in the right iliac fossa; there was no vomiting.

ON EXAMINATION.—Healthy muscular patient with a slightly dry tongue. Temperature 99·4° F. Pulse 78. The abdomen moved on respiration, but there was marked tenderness and rigidity in the right iliac fossa. His rectum, urine, heart, and lungs were all examined, but no abnormality was discovered.

OPERATION (Mr. H. C. W. Nuttall, July 27, 1936).—Gridiron incision under ether anæsthesia. The appendix was found to be normal, but a hard mass was found on the postero-external surface of the cæcum. On palpation of the mucous membrane, through the healthy portion of the cæcum, an ' ulcer ' was felt, but it was noticed that the ' ulcer ' enlarged while it was being examined. The gridiron incision was closed and a right lower paramedian incision

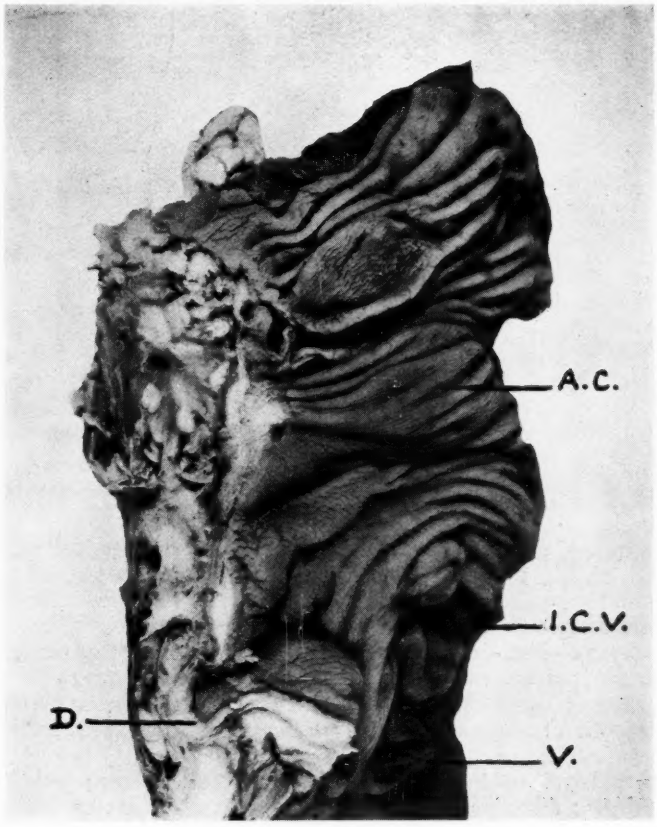

FIG. 43.—*Case* 3. Photograph of specimen. D, Diverticulum; I.C.V., Ileo-cæcal valve; V, Valve of Gerlach; A.C., Ascending colon.

made in order to perform a resection of the cæcum and ascending colon owing to the uncertainty of the pathology of the ' ulcer '. The usual resection of the right side of the colon with a small portion of ileum was carried out. The stump of the hepatic flexure was closed and an end-to-side anastomosis performed. The wound was closed without drainage. The patient made an excellent recovery and was discharged in 3 weeks.

EXAMINATION OF SPECIMEN.—This consisted of a few inches of the ileum, the cæcum, and ascending colon. In the photograph the diverticulum can be seen just opposite the ileocæcal valve and it was about 1½ cm. long before the specimen was fixed. The neck was ulcerated and was about ½ cm. wide. No concretion was present. The wall of the cæcum round the diverticulum was thickened over an extensive area. (*Fig.* 43.)

HISTOLOGY.—Sections were prepared and reported upon by Professor J. H. Dible, who found acute inflammatory changes in the wall of the diverticulum. Owing to the marked

œdema and inflammatory changes in the submucous tissue a low-power microphotograph is shown so that the mucous membrane and the muscular coat in two layers can be seen in the same field. The leucocytic infiltration could be traced up to the subserous tissue. (*Fig.* 44.)

FIG. 44.—*Case* 3. Microphotograph of section of wall of diverticulum, stained by van Gieson's stain. (× 30.)

PREVIOUSLY RECORDED CASES OF CÆCAL DIVERTICULA

1. POTIER (1912).—Female, aged 32. Abdominal pain, vomiting, and diarrhœa; palpable mass present with rigidity; size of diverticulum and position not stated; no concretion; diverticulectomy and appendicectomy performed; recovery. Pre-operative diagnosis of acute appendicitis. Microscopic examination of diverticulum not stated.

2. JACKSON (1917).—Female, aged 23. Pain in right iliac fossa, nausea and vomiting; palpable mass present; temperature, tenderness and rigidity. Size 2½ × 3 in. on antero-lateral aspect of cæcum; concretion present; partial resection of cæcum performed; recovery. Pre-operative diagnosis of acute appendicitis. Microscopic examination of diverticulum not stated.

3. MOSCHOWITZ (1918).—Male, aged 44. Pain in right iliac fossa; palpable mass present; tenderness and rigidity; diverticulum 1 in. long; concretion present; excision of diverticulum; post-operative pneumonia, then recovery. Pre-operative diagnosis of acute appendicitis. Microscopic examination—'false diverticulum'.

4. COOKE (1922).—Male, aged 53. Constipation, lower abdominal pain, and fever; palpable mass present; tenderness and rigidity. Size of diverticulum 1 in. long; concretion present ¾ in. in diameter; total excision of cæcum; recovery. Pre-operative diagnosis of acute appendicitis. Microscopic examination of diverticulum not stated.

5. FRENCH (1923).—Female, aged 29. Nausea; numerous similar attacks; loss of weight; no palpable mass; slight tenderness. Size of diverticulum ¾ in. diameter; concretion present—'very hard'; concretion extruded; diverticulum inverted; recovery. Pre-operative diagnosis of chronic appendicitis. Microscopic examination of diverticulum not done.

6. FRENCH (1923).—Female, aged 62. Pain in right iliac fossa with vomiting; no palpable mass; temperature, tenderness and rigidity; size of diverticulum and position not noted; concretion size of grape; excision of cæcum; recovery. Pre-operative diagnosis of acute appendicitis. Microscopic examination of diverticulum not done.

7. PORTER (1925).—Female, aged 60. Partial chronic obstruction for few months; acute attack 16 years ago; pain in right iliac fossa; palpable mass present; X-ray filling defect;

leucocytes 14,750; size of diverticulum ¾ in.; concretion present; resection of right colon: side-to-side anastomosis; death—gangrene of gut. Pre-operative diagnosis of cancer of cæcum. Microscopic examination of diverticulum not done.

8. PERIERA (1927).—Female, aged 54. Vomiting, pain in right iliac fossa, palpable mass present; temperature, tenderness and rigidity. Diverticulum ½ in. long, 1 in. from orifice of appendix; concretion present; excision of cæcum and part of ileum; recovery. Pre-operative diagnosis of acute appendicitis. Microscopic examination of diverticulum—all three coats present.

9. LEONARDO (1929).—Female, aged 63. Pain in right iliac fossa, nausea; no palpable mass; slight temperature, tenderness and slight rigidity. Diverticulum 1½ in. long, 2 in. above ileocæcal valve on antero-lateral surface of cæcum; concretion present; diverticulectomy and appendicectomy performed; recovery. Pre-operative diagnosis of acute appendicitis. Microscopic examination of diverticulum—circular muscle fibres present.

10. STEWART (1930).—Male, aged 54. Colicky abdominal pain; no previous attack; pain in right iliac fossa for one day; no vomiting; no palpable mass; tenderness and rigidity; no temperature. Diverticulum 1 cm × ½ cm. posterior; concretion present; resection of right colon; result of operation not stated. Pre-operative diagnosis of subacute appendicitis. Microscopic examination of diverticulum—no muscle in wall.

11. ODGVIST and PETRÉN (1931).—Female, aged 3. Previous history of bronchitis and osteomyelitis. Diverticulum 3½ × 1½ in. postero-internal with wide neck; no concretion; post-mortem examination. Microscopic examination of diverticulum—complete muscular wall.

12. EPSTEIN (1933).—Female, aged 62. Previous history of flatulent dyspepsia. Abdominal pain—third day in right iliac fossa; no vomiting; palpable mass present; tenderness and rigidity in right iliac fossa. Diverticulum ½ × ¼ in. posterior; neck $\frac{1}{16}$ in.; no concretion; diverticulectomy performed; recovery. Pre-operative diagnosis of appendicitis. Microscopic examination of diverticulum—muscle present in wall.

13. KENNON (1933).—Male, aged 26. Pain in right iliac fossa for 3 days; temperature, tenderness and rigidity; no palpable mass. Diverticulum 2½ × ½ in. posterior; no concretion; resection of right colon; recovery. Pre-operative diagnosis of acute appendicitis; during operation, tuberculosis or cancer. Microscopic examination of diverticulum—deficient muscle.

14. MCWHORTER (1934).—Male, aged 19. Colicky abdominal pain 2 days; pain in right iliac fossa; no nausea or vomiting; no palpable mass; tenderness and rigidity. Diverticulum 1½ cm. perforated antero-lateral; concretion present; closure of neck; recovery. Pre-operative diagnosis of acute appendicitis. Microscopic examination of diverticulum not done.

15. MCWHORTER (1934).—Male, aged 34. Colicky abdominal pain 3 weeks; no previous attack; vomiting 2 days; no palpable mass; tenderness and rigidity; 15,400 leucocytes; 75 per cent polymorphs. Diverticulum 1½ cm. in diameter, lateral; concretion present; excision of diverticulum; recovery. Pre-operative diagnosis of acute appendicitis. Microscopic examination of diverticulum not done.

16. THOMSEN (1935).—Male, aged 23. Epigastric pain for 24 hours; no previous attack; pain in right iliac fossa; no vomiting; no palpable mass; tenderness and rigidity; temperature 102° F. Diverticulum 2½ cm. in diameter, antero-lateral, orifice size of lead pencil; concretion present; local excision and appendicectomy; recovery. Pre-operative diagnosis of acute appendicitis. Microscopic examination of diverticulum—muscle absent.

17. THOMSEN (1935).—Male, aged 55. Cardiac pain 1 week; pain in right iliac fossa 2 days; flatulence; no palpable mass; tenderness and rigidity; temperature 100° F. Diverticulum size of nut but not inflamed; torsion of omentum—twisted six times; concretion present; invagination with purse-string suture after excision of omentum; recovery. Pre-operative diagnosis of acute appendicitis. Microscopic examination of diverticulum—complete, but rather thin muscular coat; no acute inflammation.

18. THOMSEN (1935).—Female, aged 54. Previous history of pain for 5 years. Colic, nausea, vomiting, and constipation; pain in right iliac fossa; no distension; no palpable mass; X-ray examination by meal and enema revealed no abnormality. Diverticulum size of walnut on lateral aspect; concretion present; ileo-cæcal resection carried out; recovery. Microscopic examination of diverticulum—orifice ulcerated, muscle coat thin; tuberculous ulceration of mucosa.

19. De Witt Stetten (1936).—Female, aged 35. Previous history of constipation and pain in right iliac fossa and distension; colicky abdominal pain 24 hours; pain in right iliac fossa; no vomiting; palpable mass present; temperature 100·4° F.; leucocytes 18,000; tenderness; no rigidity. Diverticulum size of tip of thumb on inner side, ¾ in. above ileo-cæcal valve; no concretion; resection of right side of colon and lateral anastomosis. Recovery; ileus for first week. Pre-operative diagnosis of acute appendicitis; during operation benign ulcer. Microscopic examination: false diverticulum; chronic appendicitis; acute lymph-adenitis in mesentery.

DISCUSSION

Diverticulosis of the cæcum has often been found associated with diverticulosis of the rest of the colon, but it appears that symptoms due to right-sided diverticula are very rare. In Maxwell Telling and Gruner's exhaustive article on diverticulitis containing a description of 92 illustrative cases, the only right-sided case was Souttar's case of a perforated diverticulum of the ascending colon. The also rare cases of secondary or traumatic cæcal diverticula occurring after appendicectomy are not being considered in this paper. Primary diverticulitis of the cæcum is very rare according to the number of cases recorded: I can only find 17 cases of the disease and 2 further cases of cæcal diverticula not inflamed. There are probably a few more cases published in inaccessible literature. The condition is probably not so rare as it appears, because it is likely that cases which have perforated and formed an abscess in the right iliac fossa are always regarded as the result of a perforated appendix. It is possible that a few cases of "appendix abscess" which have been operated upon later when a normal appendix has been found, have been cases of perforated diverticulitis of the cæcum. In 1926 Wagstaffe reported a case of acute primary typhlitis. He found acute inflammation of the posterior part of the cæcum which had become almost gangrenous, without any inflammation of the appendix: he even sent a piece for section, proving the presence of acute inflammation. His paper is completed by the statement that the pathology of the case must remain a mystery. It is also very probable that the perforation of the cæcum which occurs with a carcinomatous stricture of the colon is due to the perforation of a diverticulum rather than the perforation of a stercoral ulcer.

Ætiology.—Multiple diverticula of the colon are always regarded as acquired hernial protrusions of the mucous membrane through the gaps in the circular muscular layer produced by the blood-vessels, in accordance with the views of Hamilton Drummond, who also stated that they only occur in old people. The origin of these 22 recorded cases of solitary diverticula of the cæcum is not so clear: 11 of the cases occurred at or below the age of 35, and 13 were females. The age and sex incidence of the more usual diverticulosis of the colon is quite different: this disease is much more common in males, and is rarely seen below the age of 45. There is no doubt that a congenital cæcal diverticulum can occur, because Odgvist and Petrén described a cæcal diverticulum containing all the coats of the large intestine, opening by a wide neck near the ileocæcal valve. This diverticulum was 9 cm. long and 2·5 cm. wide, and it was found by accident in the post-mortem examination of a girl aged 3, who died of chronic osteomyelitis of the tibia and ribs associated with putrid bronchitis and amyloid disease. (*Fig.* 45.) This obviously congenital diverticulum was regarded as an ectopic Meckel's diverticulum. Greensfelder and Hiller suggest that primary solitary cæcal diverticula

are due to " the retention in some residual form of the appendix which appears early in embryological life but normally disappears before the true appendix develops ". The occurrence of enterogenous cysts in the ileocæcal region is further

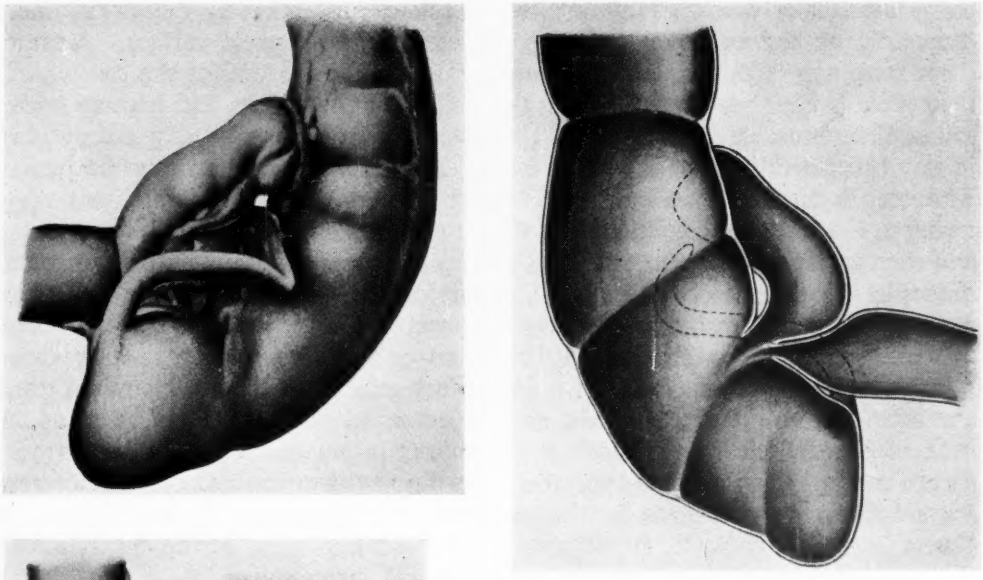

FIG. 45.—Congenital solitary cæcal diverticulum. (*After Odgvist and Petrén.*)

but only slight evidence in favour of a possible congenital origin of some cæcal diverticula. These cysts with a double muscular coat may be situated in the mesentery, in the retroperitoneal tissue, or in the wall of the gut.

The record that muscle was present in the wall of the diverticulum in at least 7 of the cases does not prove that these diverticula were of congenital origin. An acquired diverticulum can carry with it a thin layer of attenuated muscle: Hamilton Drummond compared the mechanism with that of acquired inguinal hernia. The fact that the described cæcal diverticula occurred on all aspects of the cæcum is evidence in favour of an acquired rather than a congenital origin.

A small calcified area was present in the wall of the author's *Case* 2, suggesting that a healed tuberculous focus was the cause of this acquired diverticulum with a defective muscular coat. Thomsen's third case also had active tuberculous ulceration of the mucosa. Tuberculosis, therefore, apparently causes a few of the acquired diverticula.

Pathology.—In no case was there any evidence of other diverticula. I carefully examined the resected ascending colon and cæcum (*Case* 3), and could find no trace of another diverticulum. Many of the cases had a post-operative barium enema, and 2 cases had a pre-operative radiological examination. The primary cæcal diverticula occur on all aspects of the cæcum between the tænia, more frequently on the outer or posterior than the antero-internal surface. Most of them were only about 1½ cm. in diameter, situated in the wall of the cæcum. If they grow larger they protrude from the surface of the cæcum and become longer rather than broader. The neck of the diverticulum is usually very narrow, but it may become dilated by the expulsion of a contained concretion into the lumen. The neck is also very liable to be dilated by the surgeon and his assistant while trying to elucidate the condition. In *Case* 1 the neck has been dilated by removing and then replacing the concretion and also by shrinking of the diverticulum round the replaced concretion as a result of formalin fixation. This narrow neck, although not so obvious in preserved specimens, is a most important factor in the production of acute inflammatory change. Although no concretion was present in 5 cases, I suggest that the accumulation of inflammatory exudate in the fundus might expel a concretion into the lumen of the gut. Mechanical obstruction can occur at the neck of the diverticulum without a concretion: a concretion is not an essential part of the pathology of acute appendicitis or of acute diverticulitis. The concurrent acute inflammatory changes in the appendix and in the cæcal diverticulum in *Case* 2 suggest a common factor precipitating the impaction of the concretion in the appendix and the inflammation of the cæcal diverticulum.

In microscopic sections the inflammatory exudate is most marked in the mucosa, which is often gangrenous and ulcerated, especially at the neck. The inflammation spreads through the muscularis mucosæ, causing marked thickening of the cæcum over a large area, due to œdema and extravasation of blood. The leucocytic infiltration had extended to the subserous tissue in the three cases presented, accounting for the signs and symptoms. Even a complete muscular coat appears to offer little resistance, but if it was previously attenuated it becomes fragmented. Perforation is more liable to occur if the muscular coat is deficient, leading to peritonitis or local abscess formation.

Clinical Features.—A few of the cases gave a history of previous attacks of mild diffuse abdominal pain; only one case had a long history of definite colic followed by localized pain in the right iliac fossa. F. L. Rogers and D. C. Hilton have emphasized that recurrent acute appendicitis can be simulated by this condition. One would expect the history and physical signs of a patient in an acute attack to be indistinguishable from those of acute appendicitis; and in fact there is nothing to make the surgeon doubt the diagnosis of acute appendicitis, because these patients suffer from diffuse abdominal pain which later settles in the right iliac fossa, and is associated with localized tenderness, rigidity, and mild pyrexia. Four cases had initial severe colicky abdominal pain; the other cases apparently did not suffer from colicky pain, but rather a diffuse ache. One would not expect colicky pain to be frequent, because the muscular coat of these diverticula is often deficient. Vomiting occurred in 6 of the cases, but many of the cases had no nausea and no vomiting. Although only 1 recorded case had perforated, tenderness and rigidity in the right iliac fossa were usually well marked. The pyrexia was similar to that of acute appendicitis, ranging from 99° to 102° F.

A leucocyte count was done in 3 cases and it was found to be between 14,000 and 18,000.

Differential Diagnosis.—This can only arise when the abdomen has been opened for acute appendicitis or a tumour in the right iliac fossa. Possibly the surgeon has removed the appendix but he is not satisfied that he has found sufficient pathology to account for the symptoms and signs. It is easy to miss a thickening of the cæcum even when it is present on the anterior wall. When a hard mass is felt in the cæcal wall the possibility of hyperplastic tuberculosis, malignant disease, or the reduced apex of an intussusception would occur to the operator; the possibility of diverticulitis of the cæcum would often be forgotten. If a large, hard mass was encountered, and especially if pus was found, actinomycosis would be considered.

Treatment.—Out of the 20 cases operated upon, 8 were treated by the usual resection of the cæcum and ascending colon, including a small portion of the ileum and transverse colon. The pre-operative diagnosis was appendicitis in 7 and cancer of the cæcum in the remaining case. At least 6 of these 8 cases were regarded as possibly malignant when the abdomen was opened, thus determining the procedure adopted. Four cases were treated by excision of the diverticulum with a small portion of the surrounding cæcum which was infiltrated. Eight cases had only excision of the diverticulum with closure of the neck: in the perforated case the perforation was closed and invaginated. The latter treatment is obviously the best if it is possible, but spread of inflammation in the cæcum will often necessitate a local excision of the cæcum surrounding the diverticulum.

Prognosis.—Only 1 recorded death (following resection of the right side of the colon) occurred in the 20 cases, but the result of the operation is not stated in Stewart's case. It is probable that the mortality is much higher, because cases which have ended fatally have less chance of being recorded: I also think the same applies to those that have had a stormy convalescence. Gant makes brief reference to a case of diverticulitis of the cæcum which died of exhaustion from a fæcal fistula after four weeks.

SUMMARY

1. The occurrence of 3 cases of this disease in Liverpool within three months shows that it is more common than the literature suggests.

2. There is evidence that a few of these diverticula with a complete muscular coat may be congenital, but the majority are probably acquired. Tuberculosis, either healed or active, may cause a few of the acquired cases.

3. It is a disease with a medical and surgical mortality.

4. It is of great interest to surgeons because it may be found when operating on the commonest surgical emergency. It is likely to be overlooked, and when it is found its true nature is not obvious, so that the operator will usually be dubious about the correct surgical procedure: he is very likely to perform an unnecessarily radical operation.

I wish to thank Mr. Kennon and Mr. Nuttall for allowing me to record their cases, and Dr. Howel Evans and Dr. Hewer for valuable help and reports on the specimens.

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OSTEOPOROSIS MELOLYTICA
('MULTIPLE SPONTANEOUS IDIOPATHIC SYMMETRICAL FRACTURES')

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THE purpose of this paper is to draw attention to an uncommon type of skeletal dystrophy and to put on record a case which has recently come under our notice. Essentially the disease consists of a generalized osteoporosis associated with more or less symmetrical pathological fractures which develop gradually from small localized areas of more intense decalcification. The calcium-balance is normal, and the ætiology of the affection is unknown. In 1932 Michaelis reported a case in Germany, and two years later, Milkman, in a full account of a patient under his care in America, gave the disease the lengthy title of "multiple spontaneous idiopathic symmetrical fractures".

Nomenclature.—The terminology of Milkman is at least open to the criticism of tautology, and should the employment of such a cumbersome title be legitimate or desirable, possibly the substitution of some such designation as "general osteoporosis with symmetrical fractures of the pelvis and the limbs" or "symmetrical osteoporotic fragmentation of the limb-bones" might be more aptly descriptive. This clumsy combination of words for what appears to be a definite clinico-pathological entity is to be deprecated and seems better replaced by such a nomenclature as 'osteoporosis melolytica' or 'osteoporosis meloclastica' (μέλος, a limb); this phraseology indicates an association of a definite type of pathological change in the skeletal system with an elective affinity of the process for the bones of the limbs. The preference of the adjective 'melolytica' over the affix 'meloclastica' emphasizes the doubt whether the radiological appearances exhibited by the bones really indicate true fractures and are not merely areas of intense bone decalcification; we would therefore venture to suggest that the term 'osteoporosis melolytica' be employed to designate the disease under consideration.

CASE REPORT

HISTORY.—D. H., female, unmarried, aged 24 years, was admitted to hospital complaining of pain across the bottom of her back in the lumbosacral region. She had also noticed that when getting up to walk after sitting down for any length of time she was obliged to wait a few seconds before she began to move, owing to a temporary feeling of insecurity. She had no difficulty in rising from a sitting position. The symptoms began six years ago, while she was working in the north of England as a machinist. This occupation involved sitting in a chair and working pedals with her feet. She was treated by her own doctor with iron and a temporary improvement was observed. The pain, however, recurred and she was admitted to a hospital where she was treated for six weeks with iron and liver as a case of pernicious anæmia. At the end of this time she had improved and she remained well for six months. Gradually, however, the pain returned, and two years ago became so bad that she was admitted to hospital

again, where she was X-rayed and treated with ultra-violet light and marmite. Again there was an improvement. A year ago she left the north of England and came to live in Kettering, where she obtained a position as a shop assistant. Unfortunately she found that this involved a great deal of standing, which brought on her pain again. She therefore consulted Dr. Baillie, of Kettering, who referred her to Mr. Gordon-Taylor, under whose care she was admitted into the Middlesex Hospital on June 14, 1936.

PREVIOUS HISTORY.—The patient was breast-fed. She walked and talked at the normal age, was educated normally, played games and did gymnastics. At 4 years of age she had diphtheria, followed by temporary paralysis of both legs. She had whooping-cough and measles. There was no history of any accident or broken bone.

FAMILY HISTORY.—Father and mother alive and well. Two brothers, aged 21 and 16 years, both healthy and no history of fractures.

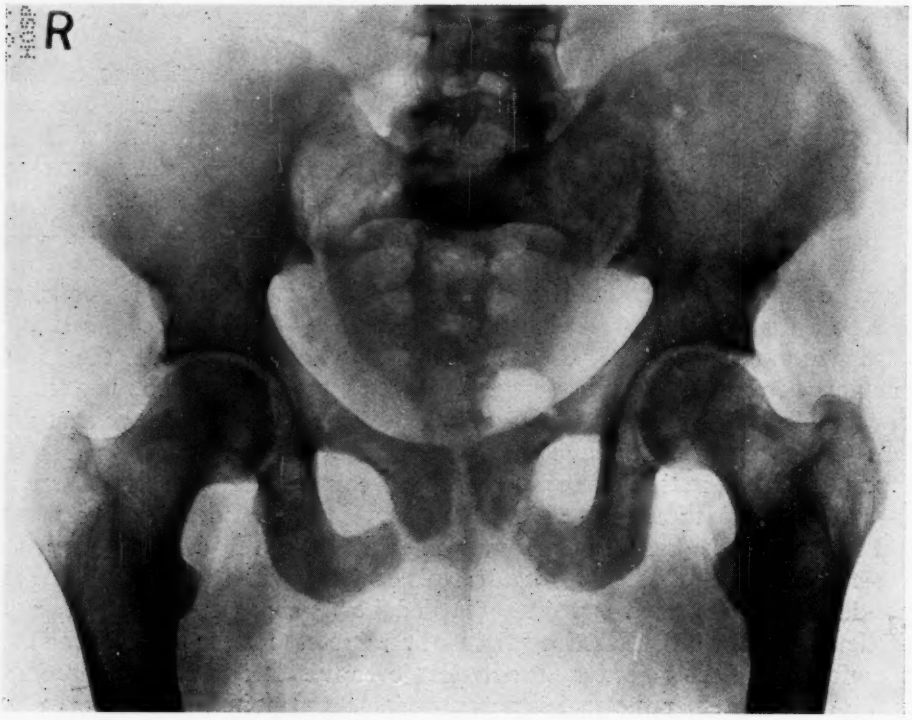

FIG. 46.—Radiograph of pelvis showing typical lesions in the rami of the pubis and the ischium.

ON EXAMINATION.—A well-nourished girl. Height 5 ft. 1 in. Weight 7 st. 3 lb. Walked with a slight waddle. Mucous membrane normal colour, bluish-grey sclerotics. Teeth good except for one carious molar. Nervous system normal. Heart and lungs normal. Slight left dorsal scoliosis with increased prominence of right hip. A fine crepitus in the right shoulder-joint, but otherwise the upper limbs were normal. Movements at the hip-joints were normal except for limitation of full abduction, which was rather more marked on the right side, and limitation of extension of both hip-joints. There was no wasting or loss of power in the lower limbs. The knee-joints, legs, ankle-joints, and feet appeared to be normal. No tenderness could be elicited on antero-posterior or lateral compression of the pelvis, or on pressure over the metatarsal bones which were the sites of fractures. Blood chemistry: serum calcium 9·6 mg. per 100 c.c., plasma phosphorus 2·2 mg. and 2·8 mg. on two occasions, blood-urea 23 mg., non-protein nitrogen 29 mg., blood-sugar 100 mg., blood-cholesterol 160 mg. per 100 c.c., blood-phosphatase 30 units. Urine: specific gravity 1020, reaction neutral, no sugar, Rothera's and Gerhardt's tests negative, total protein less than 0·005 g. per 100 c.c., no Bence-Jones protein, deposit of epithelial cells, leucocytes, hyaline casts. W. R. negative.

Blood-count: red cells 5,700,000 per c.mm., hæmoglobin 70 per cent, colour index 0·6. Film appearances: hypochromia, slight poikilocytosis and slight microcytosis, white cells 6300, differential count normal. Fractional test-meal showed the presence of free hydrochloric acid and a slowly rising curve within normal limits. The calcium and phosphorus output in the urine and fæces was normal over two periods:—

	Calcium	Phosphorus
Period 1.—		
Intake	0·28 g.	1·37 g.
Output	0·20 g.	1·39 g.
Period 2.—		
Intake	0·28 g.	1·52 g.
Output	0·20 g.	1·35 g.

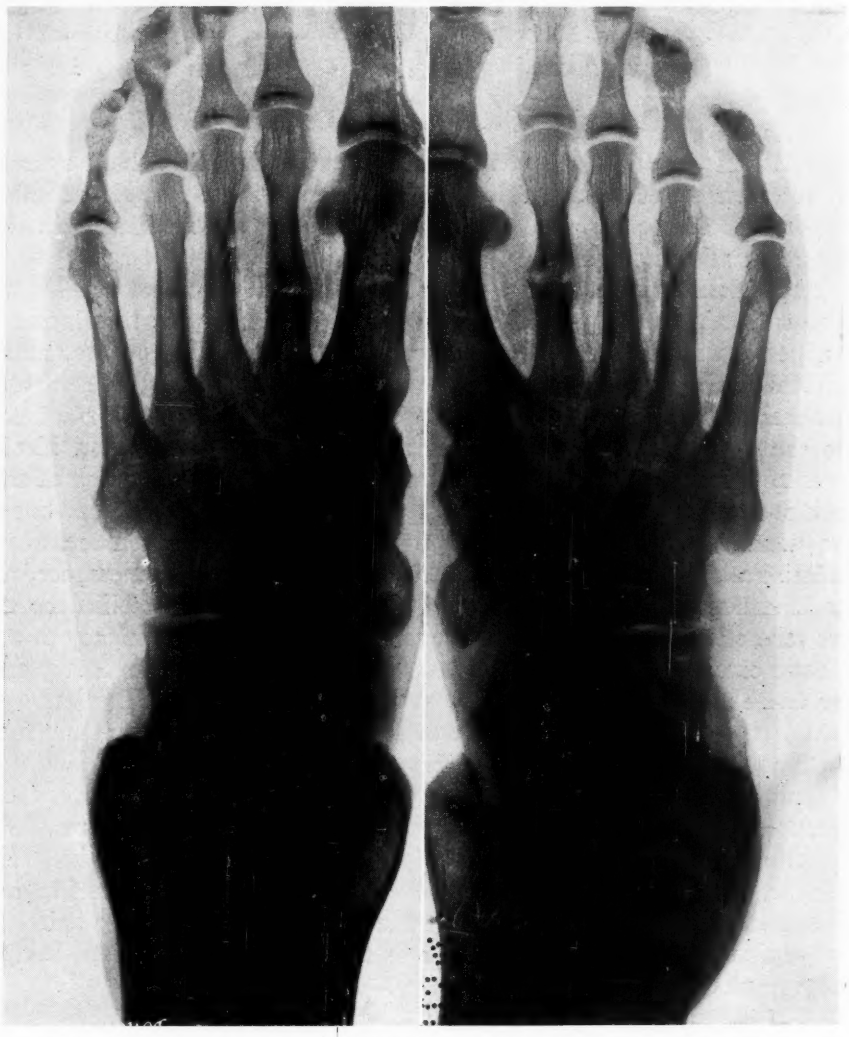

Fig. 47.—Radiograph of feet showing typical defects of the condition (*see* text).

Radiographic Examination.—The whole skeleton was examined, and all the bones showed an appreciable loss of calcium. Apart from the localized areas which will be mentioned, the decalcification was evenly distributed throughout each bone. The relationship

of cortex and medulla, or bone density balance, was maintained. In the skull there were a few areas of osteoporosis; the largest was 1·0 × 0·3 cm. in diameter. The sella turcica and vessel markings were normal. In the cuneiform of the left hand there was a small localized area of rarefaction, which may have been of the same nature as the lesions in the skull.

The pelvis (*Fig.* 46) showed typical lesions in the rami of the pubis and the ischium. On each side there was a more or less symmetrical break in the continuity of each bone. The lesions were not equally advanced on both sides. In the ascending ramus of the right ischium the fracture was complete, with an appreciable gap between the bones. In the other bones the process appeared to be more marked in the cortex, with possibly some of the cancellous medulla remaining intact. In each case the fracture communicated with the obturator foramen.

The bones of the feet (*Fig.* 47) also showed the typical defects of the condition. On each side there was a fairly well-defined linear area of osteoporosis about the mid-point of the first metarsals. On the left side this was slightly more advanced, the process extending through the cortex on the inner border. The second metatarsals showed corresponding symmetrical lesions, that on the left side being more advanced. In each case there was evidence of a small amount of subperiosteal new bone.

RADIOLOGICAL APPEARANCES

The characteristic features of these radiographs were, first, local symmetrical lesions, resembling fractures, and secondly, a general osteoporosis of all bones. The importance of the latter is not known, as it was not mentioned in the two previous descriptions.

The local lesions appear either as small circular areas of osteoporosis, as seen in the skull and in the earliest changes in the long bones, or as translucent bands which appear to spread gradually across the bone or, more probably, round the circumference, eventually leading to the solution of continuity. The edges of the bone at the site of the fracture are irregular. Immediately above and below the fracture the bone is normal in appearance. Apart from the second metatarsals there was no evidence of reaction or attempt at healing. A suggestion of sclerosis was noticed around the punctate areas in the early stage of the lesion, but otherwise the disease appeared to be entirely destructive. Callus formation does not occur.

In Milkman's case the radiological defects are similar in appearance, and by a series of radiographs over a period of years he was able to establish the gradual progress of the lesion, from a small punctate area of calcium deficiency to a translucent band extending transversely across the bone and leading to a fracture. In his case lesions did not appear in the skull or pelvic bones.

Among the lesions in the case described by Michaelis there are fractures through the ascending and descending rami of the right pubic bone, and a defect in the skull, which resemble closely the changes observed in our case. A point of difference is the slight sclerosis in the neighbourhood of the fractures. We call them fractures for convenience of description. Each is a definite break in the continuity of the bone. It is possible, however, that they are due to intense local decalcification, for there is no attempt at healing nor reaction in the neighbouring bone. Crepitus is not present, and in spite of continuous weight-bearing no deformity results except in the later stages.

ÆTIOLOGY

Dietetic deficiencies can probably be excluded as a factor in the ætiology of this disease. Although Michaelis' patient was a young man serving with the German army on the Eastern front in 1917, in whom a deficiency disease might

have been expected, yet other examples of a like nature arising in troops living under the same conditions are lacking. Moreover, our own patient's diet, and, as far as we know, that of Milkman's patient, have always been normally balanced.

In none of the cases has there been any evidence to suggest that the ductless glands were at fault. The parathyroid bodies were explored in both Milkman's and Michaelis' cases, and were found to be normal. Histological investigation of the involved bones has been of no help. In Michaelis' patient a biopsy was performed which served to rule out myelomatosis, but gave no further assistance. In Milkman's case the bones were examined histologically at autopsy, and were variously reported by different authorities to show changes typical of osteomalacia and of osteopsathyrosis, " the word being used to cover brittle bones, marble bones, and a group of other rare dystrophies including this ".

Milkman has advanced a theory that the lesions might be explained in terms of a neuro-vascular imbalance giving rise to the localized areas of intense decalcification.

In our own case, the situation of the fractures, namely the pelvis and metatarsal bones, suggests the possibility that the mild but persistent trauma, first of working a pedal machine, and later of long hours of standing, may have played a part. Against this, however, it must be conceded that the lesions may continue to multiply even when the patient is confined to bed.

DIFFERENTIAL DIAGNOSIS

Diagnosis depends entirely on the radiological appearances of the bones, and in this connection the importance of radiographs of the whole skeleton cannot be over-emphasized; especially as the radiological lesions do not necessarily correspond with the site of pain.

The early symptoms which are common to Milkman's and our own case are :—

1. Pain across the lower part of the back.
2. Momentary hesitation before starting to walk.
3. Waddling gait.

The characteristic features demonstrable in the radiograms may be tabulated as follows :—

1. Long bones and flat bones are involved.
2. The lesions tend to be symmetrical but are not necessarily so, and may be more advanced on one side of the body than the other.
3. The lesions appear as circular areas of calcium deficiency, or as translucent bands spreading transversely across the shafts of the bones and gradually leading to fractures.
4. There is little or no callus formation.
5. Displacement at the site of fracture only occurs in the very late stages of the disease.
6. There is no bending of the bones.

Osteomalacia and the 'Hunger Osteopathies'.—Brailsford refers to both Milkman's and Michaelis' case in his book *The Radiology of Bones and Joints*, and classifies them under the osteomalacias; but in our opinion there is good reason for separating the disease from this group. Osteomalacia is generally regarded as occurring in men, and more particularly women, of mature age who have been subjected to the same influences of food and environment that give rise to rickets

in infancy. Typical deformities are kyphoscoliosis, a triradiate pelvis, and bending of the long bones. Fractures are not uncommon in the long bones and are found occasionally in the pelvic bones. Preston Maxwell has pointed out that there are many cases of osteomalacia in which the chest and pelvis are badly deformed, and in which the long bones seem to escape, but when the latter are affected it is very rare for the pelvis or chest, or both, to escape. Furthermore, he has shown that when there are multiple fractures, there is nearly always evidence of bending in other parts. Although the serum calcium and phosphorus figures tend to be low, they may nevertheless be normal in cases of severe osteomalacia, and are therefore of no significance as regards the differential diagnosis. Treatment with calcium lactate and cod-liver oil or radiostol effects a dramatic cure. The pain disappears and the fractures heal. In our own patient we feel justified in excluding osteomalacia on the following grounds :—

1. There has been no characteristic deficiency in her diet, nor has her environment been in any way abnormal. She has had no pregnancies.

2. Although the multiple spontaneous fractures, the pale rounded areas in the skull, and the general osteoporosis are such as might be found in osteomalacia, there is no bending-deformity of spine, pelvis, or long bones.

3. The fractures show no tendency to heal.

The occurrence of spontaneous fractures was reported by Fromme and by Looser in cases of hunger osteopathy which they had observed at the end of the War. In Looser's cases the radiological appearances of the bone were very similar to those that we have described in our case. The fractures, or pseudo-fractures as he regarded them, had a tendency to be symmetrical in distribution, they were seen at different stages of development, and there was no displacement except in a few advanced cases where true fractures had occurred within the translucent zones. Clinically they occurred spontaneously, and caused neither pain nor disturbance of function. In the later stages of development, however, these fractures differed from those in the disease under discussion, for periosteal thickening was seen at the site of the fracture, and calcium was deposited, so that eventually the translucent areas became areas of increased sclerosis.

In Fromme's cases the radiological changes occurred for the most part at the epiphyses of the long bones, and closely resembled those of late rickets. In a few cases spontaneous fractures developed in the neighbourhood of the epiphysis, the commonest site being just below the upper epiphysis of the tibia.

Generalized Fibrocystic Disease (Hyperparathyroidism).—Our patient was at one time thought to be an example of this disease. It was excluded by the normal calcium balance, and by the radiographs, which show none of the characteristic features.

Fragilitas Ossium.—Radiographs of this condition show the cortical bone reduced to a thin shell, fractures with deformity, and evidence of repair. There is a type of fragilitas ossium in which a diffuse osteosclerosis is found—the so-called 'marble bones'; fractures occur in this type, but, again, they heal readily.

COURSE

The course of the disease can only be envisaged from the histories given by Michaelis and Milkman of their own cases, and it seems worth while, therefore, to give a résumé of these.

Michaelis' patient was a young man of 18, serving on the Eastern Front in 1917 when his symptoms began; these were diffuse pains in the feet, which spread in order upward to legs, knees, hip-joints, pelvis and sacrum, dorsal spine, shoulder-girdle and arms. In 1921 X rays showed a lesion of one foot only. By 1925 he was almost bedridden, and in 1926 X rays showed the typical lesions in the skull, left scapula, left humerus, right and left radius, second and third metacarpals on the left side, pelvis, neck of left femur, left tibia, second, third, and fourth metatarsals on the right side, and third and fourth metatarsals on the left side. The radiographic appearances then remained more or less constant up to 1932 when the case was reported.

Milkman's patient was a school teacher of 35 years who went to her doctor in 1925 on account of pain across the small of the back, pain on stooping, and difficulty in getting up from the sitting or lying position. In 1927 the X rays revealed early defects of both femora in the region of the lesser trochanters. By 1928 she could no longer walk, and from the spring of 1932 till her death a year later she was bedridden. Radiographs taken at intervals showed the characteristic increase in the extent and number of the osseous defects, which at the time of her death amounted to forty-three, and involved the following bones: ribs, cervical and dorsal spine, both femora, both ulnæ, right fibula, and left scapula. A post-mortem was held, and proved the actual cause of death to have been broncho-pneumonia with myocarditis.

Both these patients, it will be observed, were confined to their beds within seven or eight years of the first onset of symptoms. In both cases the lesions were progressive; in one up to the time of death, and in the other up to the stage when he became a bedridden invalid. It is six years since our own patient first complained of symptoms. At present she has no more than a mild lumbosacral pain, and the lesions are as we have described.

TREATMENT

In the absence of any knowledge of the ætiology of the disease, treatment can be no more than empirical. Milkman's patient failed to improve with vitamin D supplied as phosphorized cod-liver oil and viosterol, or with sunlight and ultra-violet radiation. We are treating our patient with radiostoleum and calcium lactate in the hope that it may benefit a possible disturbance of calcium absorption.

Our sincere thanks are due to the Bland-Sutton Institute of Pathology for the hæmatological investigations, and to the Courtauld Institute of Biochemistry for the calcium balance and other investigations.

To Mr. Gordon-Taylor we owe a special debt of gratitude, both for his permission to publish this case, and for his help in the choice of a title.

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SALERNITAN SURGERY IN THE TWELFTH CENTURY*

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THE twelfth century, age of Barbarossa and of Saladin, of Richard Cœur-de-Lion and Thomas à Becket, was not only a period of turmoil at home and of crusades abroad; it was also a time of new beginnings in many fields of knowledge. Europe was no longer a land of feudal baronies and of cultural centres existing in relative isolation. Great armies of knights and men-at-arms had journeyed far afield and had learned to know the great civilizations of the East. At home strong leaders were centralizing governments and creating secure courts where scholarship could take root. The intellectual stagnation of the Dark Ages in Europe was over, and the time had come to begin the hard slow climb of progress. In this renaissance of the twelfth century the physician and the surgeon took a strangely important part.

The Greeks and Romans had known a richly developed art of surgery. Their practitioners knew well how to reduce dislocations and splint fractures. They could amputate limbs, extract weapons, and (after Celsus) couch cataracts. They attempted the surgical cure of hernia, and did not hesitate to trephine the fractured skull. The last great medical writer in Greek, Paul of Aegina, prepared in the seventh century a careful summary of the Graeco-Roman surgery as it had come down to him from Hippocratic times and from Celsus, Galen, Heliodorus, and Antyllus. When the Arabic civilization came to the fore, the 6th book of Paul became the principal source of the surgical information of the great medical encyclopedists Avicenna, Rhazes, and Ali Abbas, and of the Andalusian Abulcasis, who wrote the chief surgical work of Islam. Although the Moslem surgeons dreaded the knife and added little to the art, their books at least preserved in Arabic something of the teachings of antiquity.

In Christian Europe things were otherwise. The practitioners had lost acquaintance with classical Greek. A certain amount of ancient anatomy, pathology, and internal medicine survived in a degraded form in Latin texts and translations of Byzantine origin, but none of the great surgical writers had been translated into Latin, and the only accessible texts were a trivial list of surgical names and definitions under the name of Heliodorus, and scraps of special therapy, mostly prescriptions, from Trallian, Pliny, and Soranus. Without books, the art was carried on as a body of practical experience from generation to generation, by personal example, by verbal tradition, and also no doubt by direct contact with the Saracen practitioners of adjacent Meditarranean lands, learned in written lore.

About the time of William the Norman's invasion of England, his fellow-countryman, Robert Guiscard, was conquering Sicily and the adjacent mainland. There in the year 1076 he made history, medical as well as political, by the capture

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* The Thomas Vicary Lecture delivered at the Royal College of Surgeons of England, December 10, 1936.

of Salerno. This little city on the seacoast of Campania had acquired long since a special reputation as a health resort and as the home of skilful doctors. Hither came soon after the conquest, perhaps even with the army of Duke Robert, the monk Constantine, a man who knew something of medicine and could read Arabic. For the physicians of Salerno Constantine unlocked the long-barred gateways of the past, for he gave them, in the Latin they could read, a vast array of medical translations from the Arabic. Most important among these books was the *Pantegni*, a translation of the *al-Maleki* of Ali Abbas, a complete system of theory and practice, summarizing the whole of medicine and surgery as understood by the Moslems.

Apparently inspired by the Constantinian translations, the Salernitan doctors began a remarkable revival of medical writing, producing in rapid succession a series of texts on anatomy, surgery, obstetrics, internal medicine, pharmacy, and dietetics. Crude and naive as they are, with their strange fusion of plain unlettered common-sense and half-remembered tradition with copying from the *Pantegni*, these Salernitan books began a new era of medical history.

The first surgical book to be prepared at Salerno—it may fairly be called the first modern text-book of surgery—was put together about the middle of the twelfth century. The book is anonymous and has no title; for convenience it is now called the Bamberg *Surgery*, because the oldest known manuscript (which was also the first copy to be rediscovered by medical historians) is preserved in Germany in the library at Bamberg. A second manuscript, written out a century later, is at the same place. A third but less complete copy exists at Caius College, Cambridge. Besides these three which lie in ancient libraries, it is pleasant to know that there is a fourth owned, as it should be, by a surgeon, one who would have been admired and appreciated in Salerno as he is in England and America, Professor Harvey Cushing. Through his interest this precious relic of Europe's earliest school of surgery came for a while to Rochester in New York State, to be read and studied once more in a newly-founded American hospital.

It will be clear, from what has been said, that the surgical knowledge of the twelfth century Salernitans reached them by three pathways. One way was that of oral tradition, the survival of information from classical times or at least from the days of Paul of Aegina, and probably also to some extent by direct contact with the better-informed physicians of the Arabic lands. Another way was through Byzantine texts in Latin such as those of Vindician and Oribasius, but these books contained only anatomy and medicine, not operative surgery. The third way led through the translations of Constantine. The Bamberg *Surgery* represents in the clearest fashion all of these sources. The work is not a formal systematic text-book; it is a notebook, a partially organized collection of notes, memoranda, prescriptions, and excerpts from other books. It is probably the work of many compilers, whose marginal notes and comments were absorbed into the text. Perhaps the book as we have it took several decades to grow, until it acquired final shape about the middle of the twelfth century.

The book deals with wounds and fractures of the skull, wounds of the body in general, surgical lesions of eye and ear, diseases of the skin, fractures and dislocations, hæmorrhoids, ascites, sciatica, hernia, blood-letting, and application of the cup and the cautery. The text is composed of a little theory, a little diagnosis, much operative technique, and an ample formulary of prescriptions.

The theoretical passages are practically all copied from pre-Constantinian sources. Two or three brief and garbled anatomical descriptions are taken from the so-called *Second Epitome* of Vindician, a Byzantine pamphlet which was popular in the Dark Ages. Two paragraphs on the removal of foreign bodies from the ear are taken from a book on internal medicine, the *Euporistes* of Oribasius, of which a Latin translation was at hand. The long section on blood-letting is copied, as Sudhoff showed, from an early medieval book, the *Flebotomia Ypocratis*. Through this, the Bamberg *Surgery* has a trace of British ancestry, for the *Flebotomia Ypocratis* was itself compiled in part from the still more ancient treatise on blood-letting attributed to the Venerable Bede. There are also brief excerpts from another early phlebotomy, from the *Viaticum* of Al-Djazzar, translated by Constantine, and from the ninth century *Isagoge* of Joannitius.

In contrast to all this borrowing of theory from texts of the ninth century and earlier, all the practical operative surgery is either copied directly from Constantine's *Pantegni*, or is written freshly on the basis of tradition and experience.

Some idea of the general style and method of the book may be gained from a few illustrative passages. The first five chapters, for example, contain a brief discussion of the nature of the brain and its membranes, and of the pathological effects of fracture of the skull and infection of the meninges. Like all the theoretical knowledge of the Salernitan surgeons, this part of the book is a poor confused remnant of Greek tradition; but the operative surgery described in the succeeding chapters is more worthy of its source. I quote the operation for compound fracture of the skull:—

> When a fracture occurs it is accompanied by various wounds and contusions. If the contusion of the flesh is small but that of the bone great, the flesh should be divided by a cruciate incision down to the bone and everywhere elevated from the bone. Then a piece of light, old cloth is inserted for a day, and if there are fragments of the bone present, they are to be thoroughly removed. If the bone is unbroken on one side, it is left in place, and if necessary elevated with a flat sound (*spatumile*) and the bone is perforated by chipping with the *spatumile* so that clotted blood may be soaked up with a wad of wool and feathers. When it has consolidated, we apply lint and then, if it is necessary (but not until after the whole wound has become level with the skin), the patient may be bathed. After he leaves the bath, we apply a thin cooling plaster made of wormwood with rosewater and egg. Make it thus: mix the wormwood with the white of egg and the rosewater, and beat thoroughly. On the following day apostolicon should be applied so that if any water has appeared in the wound or entered it, it may be removed and the wound restored to condition. To make (apostolicon) take pure wax, 6 ounces; mastic and olibanum, of each 2 ounces; galbanum, ammoniac, of each 3 ounces; naval pitch, 1 pound; colophonium, 1 ounce; turpentine, 2 ounces. To prepare this, put all the ingredients in an earthenware vase and finally melt the wax on a slow fire and strain through a cloth which is suspended over cold water. Gather it into one mass; then it is extracted near the fire and troches are made and when necessary are applied to the skin or inserted into the wound, above which we apply the waxy residue, which is thick and dry, in order that the pus may not run down. Above this another dressing is placed in order that the inner dressing may not become soaked with pus, because just as a sea sponge takes up water, so a linen cloth takes up pus, and thus the inner dressing is prevented from becoming laden with pus.
>
> Bamberg *Surgery*, Cap. 2.

Even though the Salernitan surgeon was merely repeating an operation well known for a thousand years or more, and better described in Greek and Arabic

books than here, nevertheless his words are those of a man with first-hand experience, well knowing the perils and sequelæ of a cranial injury. In one respect he knew better than the Greeks, for in this passage he refrains from the use of oily applications to the cerebral membranes, and in another chapter he specifically forbids them. This sound advice is evidently based upon the discovery by trial and error—without benefit of the microscope or of bacteriology—that the use, in cranial wounds, of oils and ointments made up in a medieval pharmacy was likely to stir up pus and inflammation.

This passage is original, that is to say, not copied from a written source. In contrast I quote next two brief excerpts from the section on eye lesions. These represent Arabic surgery directly copied from the *Pantegni*. The first deals with the treatment of adhesions of the eyelid :—

FIG. 48.—Operation upon the eye, from a thirteenth century manuscript of Roger in Trinity College, Cambridge. (*After Sudhoff*, 1914.)

If the cornea or conjunctiva become joined to the eyelid, the latter is elevated by an iron instrument inserted between the lid and the eye (*Fig.* 48), avoiding the membranes of the eye. Cut the fleshy adhesion. When this has been done you should masticate salt and cumin together in your mouth and expectorate it into the eye. We then bind upon the eyelid a wad of wool soaked in white of egg and reapply it twice a day until the third day. After the third day, it is washed with old rosewater and other things, namely juice of verbena and wormwood.

Bamberg *Surgery*, Cap. 54 ; *Pantegni*, Practica IX, 27.

Next, an operation for " catarrh descending into the eyes " (probably post-herpetic neuralgia) :—

Catarrh descending into the eyes causes a sensation as if ants were crawling through the forehead and temples. The patient's face becomes strongly reddened. In this disease, therefore, the temples and forehead are shaved, the muscles of the temples

> are located by moving the lower jaws, and the skin is incised down to the bone by even, straight cuts in three places, avoiding the muscle. These incisions of the veins are made at a distance of 2 inches from each other. When this has been done, an iron instrument is pushed from one incision to the other between the skin and the bone, and turning the edge of the knife toward the skin when the arteries and veins are found, the skin is cut and from the edges of the incision the blood is permitted to run abundantly, and when no more remains the vein is compressed. When the place has been perfectly purged, it is packed with a linen cloth and treated like other wounds.
>
> Bamberg *Surgery*, Cap. 50; *Pantegni*, Practica IX, 22.

It is difficult to select a passage to illustrate the theoretical passages picked up from Byzantine sources, because they are so very confused that they can hardly be translated intelligibly. The section on fractures and dislocations, for example, is preceded by a paragraph on the skeleton, taken from Vindician, which is scarcely more than gibberish. I give here a passage about tetanus, no doubt also from some such ancient text:—

> There are three kinds of spasm, one called empisteon or emprosthotonus, one called prostocon or empitostonos, another tetanus. Empitostonos is Greek for 'holding the back', emprotostonos is Greek for 'holding the front', tetanus for holding the whole body or all the time. Spasm is sometimes due to repletion, sometimes to inanition; sometimes it is fatal, sometimes not fatal, so that Hippocrates says in the *Aphorisms*: "Spasm caused by hellebore is mortal, spasm supervening upon a wound is mortal, as well as spasm or hiccough due to large loss of blood".
>
> Bamberg *Surgery*, Cap. 78.

The following passage is a typical example of Salernitan didactics:—

> Distemper of the humors causes lepra, of which there are four kinds, namely, leonina, elephantia, tiria, allopicia. Allopicia comes from phlegm and is compared to the wolf because those who suffer from this kind of lepra become depilated like wolves. Tiria comes from black bile and is compared to tirus, because just as a tirus, when he itches, scratches himself between his spines until he loses his prey, so those who suffer from such a humor scratch at themselves all day long. Leonina comes from red bile and is named from the lion because just as the lion is hotter than all other beasts, so is this disease hotter than others; or perhaps because the lion is varicolored, and so do these patients vary in their colors. Elephantia comes from blood and is named from the elephant because blood is the most plentiful of all the humors just as the elephant is the largest among animals.
>
> Bamberg *Surgery*, Cap. 40.

Space does not permit citation of other passages as further evidence of the mingling in this book of the dimly-remembered lore of ancient Greece, of Byzantine theory, and of Arabic operative surgery. At first glance one sees in the Bamberg *Surgery* nothing but these traditions and copyings, in various stages of degradation. Closer study, however, reveals a few astonishing innovations. Here is an optimistic effort toward surgical anæsthesia, the so-called "soporific sponge" soaked in juice of hyoscyamus and poppy, previously described only in ninth and tenth century books of prescriptions and now appearing for the first time in a formal book on surgery. Here is advice to trephine the skull (*Fig.* 49) for epilepsy (a thing suggested neither by Greeks nor Arabians), and the first detailed account of a truss for inguinal hernia. Here is the first practical suggestion of intestinal suture,

and the first treatment of goitre (at least in the Occident) with substances containing iodine.

FIG. 49.—Trephine operation upon the skull, from an Oxford manuscript. (*After Sudhoff*, 1914.)

We shall come back to the matter of intestinal suture. The passage about goitre reads as follows :—

> A collection occurs in the throat which is called bozum which we are well able to cure : ℞ Asparagus, bruscus (*Ruscus aculeatus*), cyclamen, polypodium, viticella root, cucumber, wild cucumber, aristolochia rotunda, yarrow root, seaweed, marine sponge, branca ursina, saponaria, the milk of a sow nursing her first litter, and roots of thapsia. Prepare as follows : Dry all the ingredients in the sun or in the oven, then grind and sift them, then burn the seaweed and the sponge and mix it with the foregoing to make an electuary. When the patient retires, put it under his tongue.
>
> Bamberg *Surgery*, Cap. 32.

It has been stated that this use of the sponge was previously known to the Chinese, but it does not appear in Greek medicine, nor did it find its way into the *Pantegni*. It must have been invented in southern Europe, or, if actually known in the distant Orient, came overland to Europe by the caravan routes some time before the twelfth century. Possibly it represents only a fortunate coincidence. Medieval therapy made use of an immense variety of substances, most of which obtained their place in the pharmacopoeia on purely empirical grounds or because of some assumed relationship, no longer tenable. We must not take it for granted, simply because modern knowledge shows a drug to be rational, that its original introduction was achieved by an act of reason. The ashes of sponge had been already in use for centuries as a styptic. It was well known in Salerno that goitre was more prevalent in the Alps than near the sea ; some genius among the

profession may well have undertaken to exhibit to the patient, if only for symbolic reasons (in accordance with the doctrine of signatures), a medicine typical of the sea.

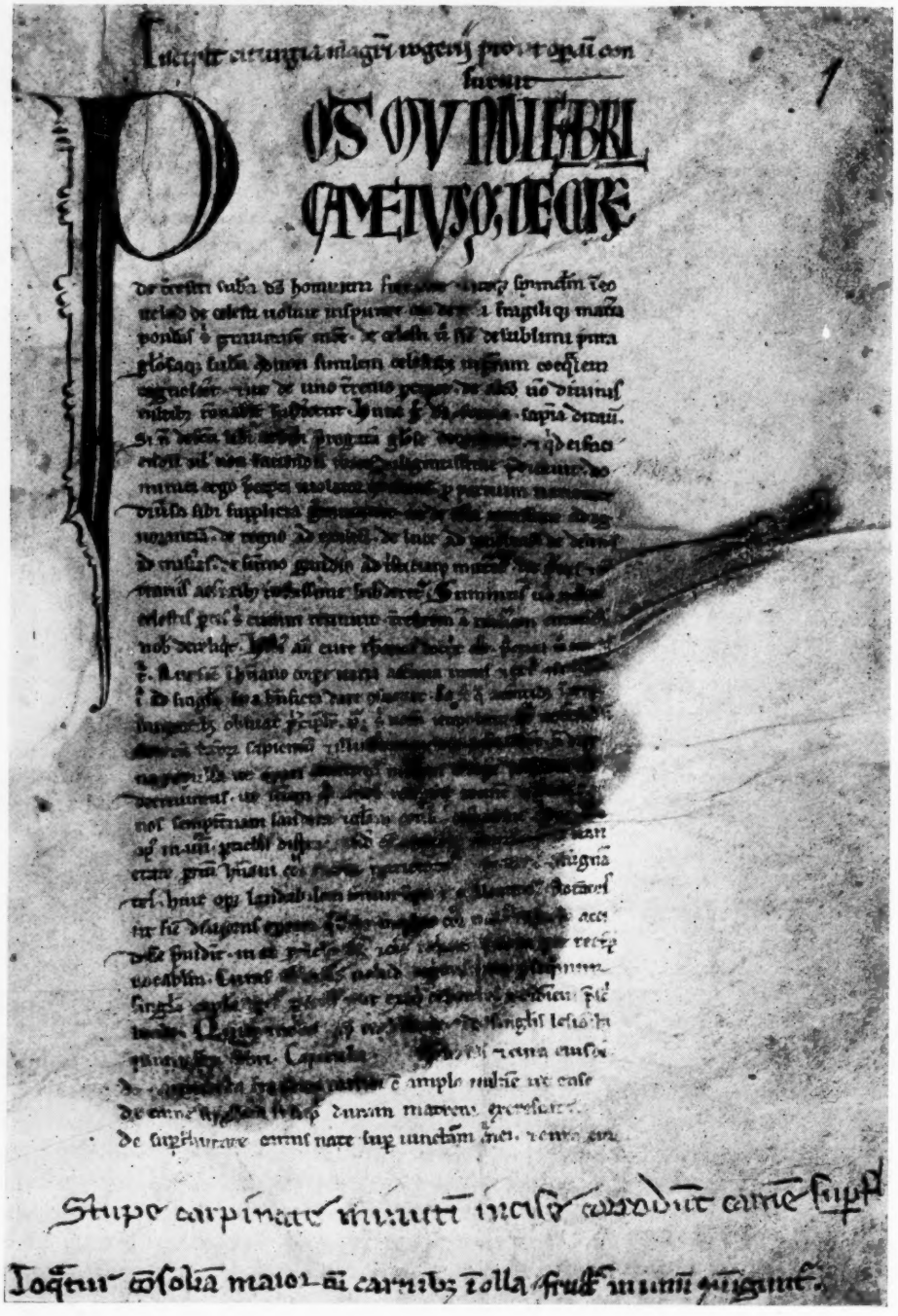

FIG. 50.—First page of the Cushing manuscript of the *Surgery* of Master Roger.

Twenty years or thereabouts after the preparation of the Bamberg *Surgery*, there appeared at Salerno a very different book, the *Surgery* of Master Roger (*Fig.* 50). Something of the circumstances surrounding its compilation in the year 1170 is told us in a colophon at the end of the earliest known manuscript :—

> This work was arranged in light and order by Guido Aretino, a servant of the profession of logic, at the request of his distinguished colleagues and by the permission and desire of the eminent doctor, in the year after the incarnation of our Lord 1170, and in the fortunate reign of most glorious King William.
>
> Here ends the *Surgery* of Master Roger Frugardi, completed by Master Guido Aretino, his disciple and approved by the teacher himself.

Guido Aretino, " logice professionis minister ", was a man of piety as well as learning, for he began the book with the following prologue :—

> After the foundation of the world and its adornment with terrestrial substance, God desired to create man and to breathe the breath of life upon him from on high, and he wished man to know that even as he had in him the burden of his heaviness from base and fragile matter, yet also there was in him from high heaven a pure and glorious substance, by which he might know himself like unto his Maker, and coequal to the angels in glory; and as from one he took an earthly garb, by the other he was clothed in heavenly apparel. Creating him therefore, God endowed him with wisdom without defect, adorned him with the glorious prerogative of free will, and fully set forth what he might and might not do. Therefore when a violator of the divine precepts came into being, he caused to spring up divers penalties for himself according to the variety of his parts, so that he was turned from perfect knowledge to ignorance, from his kingdom to exile, from light to darkness, from bliss to misery, from the highest joy to sorrow, and was most justly subjected to evil and hostile misfortunes. The Great Physician kept for himself the care of the celestial regions, leaving to us on earth the cure of our own suffering. This treatment is given us by Theory, and is administered by Practice, which provides the appropriate relief for each of the various disorders which afflict the human body from within and without. That art which primarily protects against disorders arising within the body takes the name of Practice, while that which defends us against corruptions coming from without and doing harm in the body by dissolving continuity, calls itself in all worthiness of name and service, Surgery . . . we have determined to set forth in writing, in a well-pondered way, how we are accustomed to operate, so that those who receive it from us may be able to retain it and we may earn for ourselves eternal praise and glory. We deliberately arrange to divide the work into four parts so that by properly assigning the various treatments according to the various parts of the human body, we may be able praiseworthily to finish the work; noting that a diligent operator, foreseeing that certain diseases occur in the four parts of the body, may seek the treatment and signs in that part of this work which corresponds to the given region.

The book thus earnestly begun is a systematic text-book of operative and medicative surgery, arranged in anatomical order from head to foot. The work is strictly practical. All the petty Byzantine anatomy and pathology is gone, as well as the ninth century uroscopy, and even diagnosis is reduced to a minimum. The entire text is cast in new and original words, excepting a few paragraphs, mostly prescriptions, which are copied from the Bamberg *Surgery*. These borrowed paragraphs happen to include some which had themselves been taken from the *Pantegni* and from Oribasius, but otherwise no pre-Salernitan author is either cited or plagiarized in the *Surgery* of Roger.

The surgical practice, like that of the Bamberg *Surgery*, is in general that of the Greeks as it had come down through Hippocrates, Galen, Celsus, Paul of Aegina, and Ali Abbas, but of course abbreviated, simplified, and somewhat

degraded in transmission. Although Master Roger and his pupil Guido had at hand a great comprehensive treatise of the ancient surgery, namely the 9th book of the *Pantegni, pars practica*, and although they were surely influenced, indirectly at least, by the Constantinian translations, there is nothing to prove that first-hand use was made of the *Pantegni*. Certain precedures regarded as useful by the ancients, and cited in the *Pantegni*, are not quoted by Roger—for example, the demonstration of a fissure in the cranial vault by the use of ink, and the treatment of nasal polyps by sawing with a string.

Such was not the case in other fields of Salernitan medicine. The *Anatomy* of Ricardus and that of Master Nicholas, for example, which are approximately contemporary with Roger, were largely copied from the *Pantegni*. It appears that the surgeons were practical rather than bookish men, and tended (as surgeons still tend to a certain extent even in our own times, especially with regard to operative surgery) to learn by local example and contact more than by reading. It is obvious also that the surgeons, being inheritors of a necessary art, which had to be practised even in unlettered times, had less to learn from the new books brought in by the translators than did the teachers of anatomy or even the medical practitioners, whose traditional sources had become inaccessible during the Dark Ages.

In order to gain an idea of the surgical art as it was practised at twelfth-century Salerno, let us turn to Roger himself, and see how his patients fared who came with a fracture or dislocation, a tumour or an infected wound.

The victim of a hostile battle-axe, carried in with a fractured skull, would have been well treated, as already indicated by a passage I have quoted from the Bamberg *Surgery*; Roger gives an even fuller discussion of this subject. Clean wounds were usually dressed with lint or cloths soaked in white of egg, or sprinkled with a resinous powder called "pulvis ruber". Large wounds were closed with interrupted sutures of silk, with a cloth wick at the most dependent part. Arrow points and spear heads were removed whenever possible, after careful analysis of the problems presented by the form of the weapon and its position:—

> If the patient is struck with a spear in the face, through the nose, close to the eye or jaws or elsewhere (*Fig.* 51), so that the weapon penetrates deeply or enters narrow and tortuous places, it may be very difficult to extract it; but let the surgeon use his intelligence and think carefully how he may extract it. If the weapon is still attached to its shaft, a probe may be inserted along the shaft down to the iron, and if the latter is found to be firmly attached, the shaft is shaken little by little and the wood and iron thus released may be carefully removed. But if the iron head is detached from its shaft, let the patient recall how he was standing when he was struck and whether he was struck upward or downward, from right or left. A probe may then be inserted into the wound, the path of entry determined, and a decision made as to whether the weapon can be extracted. If it cannot be removed without great damage, it is better to let it remain; many people have lived long with weapons imbedded in them.
>
> ROGER, I, XX.

Wounds of large veins, for example in the neck, were treated by ligation with thread. When ligation was impossible the red powder was used to prevent clotting, or rabbit's hair or asses' dung used either dry or (in emergency) fresh. This use of what we now know to be infectious materials is excused by the fact that all such military wounds were expected to suppurate anyway. They were frequently drained with strips of bacon instead of cloth wicks, and were poulticed to induce the flow of pus.

With regard to nerves, experience had taught the important lesson that a clean transverse cut, well alined, would heal better than a diagonal section.

Old infected and fistulous wounds were treated by enlargement with the knife or probe, mortified with a corrosive ointment containing quicklime, and thereafter packed with bland styptic ointments. It was recognized that fistulous tracts originating in bone (osteomyelitis) should if possible be cleaned back to healthy tissue.

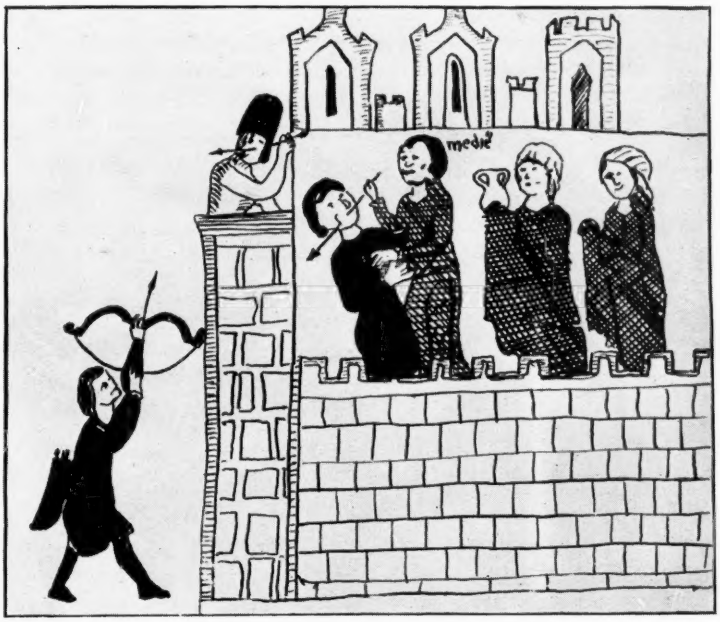

FIG. 51.—Military surgery, from a Berne manuscript. (*After Capparoni.*)

The limitations of traumatic surgery were well defined. " If a man is wounded in the heart, lung, liver, or diaphragm we do not undertake his treatment " (ROGER, III, xxxv). " If the spine is wounded transversely and the cord remains corrupted internally, we believe it is scarcely or never cured by surgery " (*Ibid.*, xxxix). " A wound of the kidneys rarely occurs, but when it happens we commit its treatment to the grace and goodness of God, not to our own work " (*Ibid.*, xli).

This conservatism regarding visceral wounds renders all the more striking the Salernitans' one great step in abdominal surgery, mentioned in the Bamberg text and clearly described by Roger, namely, a method of repairing the wounded intestine :—

> If the intestine becomes herniated by any wound of the body and if there is a longitudinal or oblique wound so that the greater part remains uninjured, we are accustomed to treat it as follows. In the first place, if the weather is cold when the intestines are injured, a live animal is cut down the middle and laid upon the intestines and left there until the intestines become warm and regain their natural heat and become softened (*Fig.* 52). In the meanwhile, a cannula is made of elder wood in the shape of the wound of the intestine, but one inch longer than the wound at each end The cannula is made thin. It is inserted through the wound of the intestine and the wound is sewed with a sharp needle and a silk thread. The cannula is placed there in order that the contents of the intestine may pass through it and that the suture of

the wound may not make an obstruction. When this has been done the dirt is washed gently from the intestines with a sponge well soaked in warm water. When they have been thoroughly cleaned the intestines are replaced in the abdomen through the wound by which they escaped, and then the patient is placed on a plank and shaken in order that the intestines may slide into their proper position, but if the wound was such that they cannot be replaced, it is made larger and thereafter the wound is left open until you see the intestine stuck together. After suturing the intestine red powder is placed over it. After the wound of the intestine is consolidated the external wound is treated by suture and otherwise as said above.

ROGER, III, viii.

FIG. 52.—Use of warm animal body to aid in reduction of intestine herniated through wound, from a thirteenth-century *Surgery* of Roland in the Bibliotheca Casanatense, Rome. (*After Carbonelli.*)

In dealing with tumours the Salernitan surgeons were on the whole rather bold. Cancer, or whatever they identified by that name, was completely excised by knife or cautery if its location permitted such drastic treatment; otherwise it was attacked by corrosive ointments. When deep among nerves and arteries it was left alone, for Hippocrates himself had said: "Those who have cancer in remote places it is better not to treat than to treat, for when treated they quickly die, when not treated they survive a long time."

Tuberculous glands of the neck, when large and prominent, were radically excised, and perhaps still more surprisingly, goitrous thyroids were also removed by the surgeon. According to both the Bamberg *Surgery* and that of Master Roger, the patient was first to be given a course of treatment with a drug containing ashes of sponge and seaweed. If this trial of what we now know to be a course of iodine therapy failed to reduce the tumour, recourse was had to operation:—

If the goitre is single, with the aid of a hot iron we put in one seton lengthwise and another from side to side and apply over them a cloth soaked in egg or in lard. Every day, morning and evening, the setons are drawn toward the outside until finally the flesh is cut through. When this is done, if any part of the goitre remains, powder it with powder of asphodel and purified in this way the wound will heal like other wounds. If the tumour is not provided with too many arteries it may be removed by grasping it firmly in the hands and cutting the skin carefully lengthwise. The tumour is grasped with a hook and the skin is dissected away. A finger is then inserted through the wound and the goitre removed entirely with its capsule. The wound is lightly dressed with a linen cloth. If the hæmorrhage is excessive we apply those remedies which have been described above for this purpose in the chapter on arrow wounds in the neck. These remedies are continued for three days. Afterward if any of the tumour remains, apply powder of asphodel, following it by egg, and then proceed as in other wounds. The greatest care should be taken to avulse the capsule of the goitre completely so that nothing is left, for if the slightest part remains the patient relapses. When the wound is entirely clean, it may be dusted with red powder and sutured as we have described elsewhere, and it will be cured. If, however, the goitre is very large and the patient weak or elderly, in our judgement it is best to refrain from this treatment. These large goitres usually have several lobes which makes them difficult to dissect away, and we avoid treating them with a hot iron for fear of injuring the arteries or nerves. When, however, it becomes necessary to treat these patients by surgery, we tie them to a table and have them held firmly in order that we may see exactly what we are doing.

ROGER, II, xv.

If my readers are unable to believe that any such operation, done without benefit of anæsthesia, asepsis, or hæmostatic forceps, could even possibly be survived by the patient, their faith may be restored by the tale of a similar operation performed in America only a few years ago, as related to me by Dr. John M. Armstrong, a distinguished surgeon of St. Paul. A Red Indian of the Chippewa tribe in Pine County, Minnesota, Jim Razor by name, suffered for years with a goitre as large as a man's two fists. One summer, however, when Dr. Armstrong returned for his annual camping and hunting trip he was astonished to find that Jim Razor had been cured of his tumour. Inquiry of the local game warden disclosed that the tribal medicine man, Bezonagezic, had become alarmed at the growth of the tumour and had removed it. According to the warden's story: "They got four big heavy squaws to hold him down—held his legs and arms—while the medicine man cut it out with his hunting knife and sewed it up overhand stitch with yarn and darning needle". The yarn is said to have been obtained by unravelling an old sock, and the needle was a large one of the kind used by the Indians to sew garments of buckskin. Jim Razor lived five or six years after this operation.

It is clear, from the Salernitan descriptions, that such difficult operations as those for scrofulous glands and for goitre were undertaken only when the tumours were very prominent. Knowledge of anatomy was far too slight to permit anything approaching a surgical dissection of the neck. Roger declares indeed that "no scrofula or gland is ever to be incised or cut until it can be held and drawn out in the hand" (II, xiii), which reminds me of an old surgeon in Baltimore, thirty years ago, who claimed that he had never failed to find a foreign body embedded in the tissues—because he had never cut down upon anything he could not feel beforehand.

Fractures were sensibly treated; they were set, splinted (*Fig.* 53), and protected when necessary by feather pads or supported with starch dressings made

with wheaten flour. Compound fractures were treated with surgical dusting powder and were dressed with fenestrated bandages to permit drainage. Master Roger evidently expected to cure some of his compound fractures, and treating them as he did in the home or camp he may well have had a lower mortality rate than prevailed later in the pus-laden pre-Listerian hospitals of England and America, where the victims of major compound fractures were more than likely to die of septicæmia or gangrene.

Roger's treatment of dislocations provides an especially instructive comparison with the ancient methods, for in this branch the Greeks were at their best. In the Hippocratic book *On the Articulations*, for example, four types of dislocation at the hip are described and appropriate methods of reduction are advised. All the old writers from the Greeks to Ali Abbas repeated this information. Roger enters into no such subtleties: a bone is out of joint, it is to be put back and no questions asked. His method of reduction of any given luxation is more or less like the standard ancient method for the common type at that joint, simplified and sometimes a little muddled. As I quote his passage on dislocation at the shoulder, it will be noted that Roger has confused two different instruments of leverage used in this reduction, the ball and the pestle, into one unhandy hybrid; and also that the second, more drastic method is given so incautiously as to threaten a terrible jolt for the patient; but in spite of these lapses we still recognize the tradition of Hippocrates.

FIG. 53.—Treatment of fracture by splinting, from a thirteenth-century manuscript of Roger in French, in the British Museum. (*After Sudhoff*, 1914.)

> If the humerus is dislocated from the shoulder-blade, we are accustomed to treat it thus. The patient lies supine and a stone or log is taken. Have one end somewhat sharpened and the other end more round. Threads are wound upon it as if it were a ball of thread, and this round object is placed under the armpit, and the doctor places his foot upon it. Pressing hard with his heel, and elevating the bone with his hands, he reduces the humerus to its proper position, and before the ball is taken away a piece of fabric infused in white of egg is bound on with a long bandage and the ball is placed under it and is bound with another bandage, and a cushion is placed under the arm so that it is held in suspension . . .
>
> It happens sometimes that a dislocation cannot be reduced in the way mentioned, and then a long, rather broad stick of wood is prepared, and in the middle a hole is made in the shape of the aforementioned ball, and the ball is introduced into it from the larger side, and the log is held strongly by two men, and the patient is placed upon a stool, and the ball is put in his armpit. The doctor holds the forearm and the humerus firmly on each side, and the men who are holding the log elevate it. Then let someone take the stool away from under the patient, and while he is thus hanging, the humerus will be reduced to its proper place. (*Fig.* 54.)
>
> ROGER, III, xvi.

FIG. 54.—Two methods of reducing dislocation at the shoulder-joint, from a thirteenth-century manuscript of Roger in French, in the British Museum. (*After Sudhoff*, 1914.)

Now and then Master Roger, or the devout Guido, fell into still deeper confusion. Their chapter on diseases of the anus, for example, treats hæmorrhoids and condylomata as one disease, although the two conditions are quite distinct in all the older books, including the *Pantegni*. Again, the ancients had worked out two surgical methods for fistula in ano; in one, they inserted a sound through the fistula and cut down upon it, in the other they passed a ligature, tied its ends over the anal margin, and tightened it daily until the fistula was laid open. Roger confuses the two methods, and proposes to pass and tie the ligature and then next day to cut down upon it.

There are some things in this twelfth century book to which we would now apply the word 'medieval' in its worst sense—for example, the treatment of acute insanity :—

> For mania or melancholy a cruciate incision is made on the top of the head and the cranium is perforated, to permit the noxious material to exhale to the outside. The patient is held in chains and the wound is treated as above under the treatment of wounds.
>
> ROGER, I, xxvi.

The dreadful operations of bleeding and scarifying the temples which the ancients devised in their despair, for facial neuralgia and ophthalmia (one of which was quoted above from the Bamberg *Surgery*), are retained by Roger. He used, of course, the incredible seton, so completely gone from twentieth century practice that our students do not even know what it was.

> For the spleen, let a seton be applied in the left hypochondrium above the spleen. Some, however, apply two, one of them distant from the other. . . . For pain of the spine, let three setons be applied, one in the middle of the spine, another three finger-breadths above, a third three finger-breadths below. . . . For pain of the testicles a seton is placed in the scrotum.
>
> ROGER, III, xlv.

To relieve those arthritic and neuralgic pains for which in our milksop times we mildly bake the back or limbs, Roger (like his Arabic predecessors) applied the actual cautery, with large irons well heated in the fire :—

> For sciatica, three cauterizations may be made above the hip over the joint, or a triangular cauterization may be made there. For gout, cauterize in the hollow place under the foot. As a remedy for the whole body, the cautery is applied in two places to the tibia, three finger-breaths below the knee and the same above the ankle joint.

Counter-irritation by actual cautery, like that by the seton, has been given up, but it lingered for a long time in human surgery, still longer in veterinary practice, and there are even yet places in rural America where a spavined horse is treated after the rules of Abulcasis and of Roger.

The almost total absence of magic and incantation in the Salernitan surgical text-books is quite remarkable, considering how closely they followed upon the era of monkish medicine. In some of the Bamberg manuscripts there is a kind of charm for wounds—a cord of sheep's intestine hung about the neck, with prayer—but Roger's only hint of the supernatural is a pleasant bit of moon-magic for swollen glands :—

> In the waning of the moon, but while there are yet eleven days of the moon, take eleven wafers made from the roots of gladwin and of wild radish, on the next day ten, on the next nine, and so to the end of the moon, decreasing by one each day. If this medicine does not succeed, recourse must be had to surgery.
>
> ROGER, II, xiii.

Neither Roger's predecessors nor all his successors in the next centuries were so free from hocus-pocus. Even so well educated and thoughtful a man as John of Arderne did not despise the power of magic. It is amusing to note that someone who owned, in the fourteenth or fifteenth century, the Salernitan surgical manuscript now belonging to Dr. Cushing, not sympathizing with its secular austerity in this respect, added on a flyleaf an impressive incantation :—

> For the farcy of horses, commonly called *vermis*, which erodes between the skin and flesh : Take the horse by the right ear with your right hand before sunrise. Do this early in the morning for three days and say into his ear : " When our Lord Jesus Christ was born, he was well born ; when he spoke, he spoke the truth ; what he did was well done ; blessed be the Lord God." Then say the Pater Noster all through and the Ave Maria and afterward say : " Thus I believe, that this horse will recover from this infirmity of the farcy." Whatever may be the horse's colour, let that colour be named. Say all this to him into his ear three times in the three days and lead the horse about, three times after sunset.

The prescriptions which abound in the Salernitan manuscripts come from the same various sources as the operative surgery. Some of the compound drugs bear ancient names, well known in classical times, as, for example, " marciaton ". The names of others suggest their invention in the days of monkish medicine, for example " apostolicon ", the very name of which confers a benediction, although it was only a sticking-plaster of composition somewhat like that useful product, sticky fly-paper. These old prescriptions occur repeatedly in the ninth- and tenth-century formularies. Others no doubt were concocted or modified to suit contemporary taste. The Bamberg *Surgery* runs to long and complicated mixtures, Roger in general to shorter and more rational formulas. Among the irrelevant ingredients of his powders and ointments there is often something useful to be found, witness his goitre medicine containing ashes of seaweed, and his lotions for superficial burns, which contain bland oils, mild alkalis, or a tannic decoction of pomegranate

bark. Filthy or disgusting ingredients are rare, and when called for they are usually more or less rational. When Roger was faced with the problem of draining deep fluids from the ear he prescribed the oil of mice boiled with tallow. Mice are obviously good at getting out through a small hole—and in any case the medicine was thick, oily, and hot, like most of the favourite remedies for earache.

From what we have seen, both good and bad, of the Salernitan surgery, it becomes more and more clear that in Europe during the Dark Ages the great surgical tradition of Greece and Rome had almost run its course. Even at Salerno the Art had become reduced to a small body of practical information, part of it clearly remembered and not inexpertly applied, part of it sadly garbled and obscure. Little improvement had resulted from the recovery by Constantine of the surgical text of Ali Abbas, itself only a larger relic of antiquity, unoriginal, uncritical, and incomplete. Upon these fragments of the past the Salernitan surgeons began to build again. It is well that the task fell to men like Roger Frugardi. Such men could be trusted with the surgeon's knife, for on the whole they were cleanly, conscientious, and not meddlesome, considering their time. Being practical men, they were safer than others of their age from the dangers of unfounded speculation. They were eager to teach and therefore could not cease to learn; by that one timeless virtue we know them as brothers to the great teachers of our own day.

When Guido Aretino began to set down on parchment the fourth and last division of his book, he wrote in all the pride of a task well done: "Let the diligent reader study carefully what I have learned of the art . . . and let him labour to build upon this as upon a steady foundation, that he may deserve for himself eternal praise and glory". This hope was richly realized. Before the twelfth century was over, the book found many diligent readers, and was copied in manuscript again and again. The later surgeons of Salerno and of other nations, as the work became more widely known, wrote their own notes and comments upon the margins of their copies and on the fly-leaves. When the manuscripts were again transcribed, these glosses often became merged with the text, and so the *Surgery* of Roger grew larger and underwent gradual change, until finally it was transformed into the books we know as the *Surgery* of Roland of Parma, and the *Surgery* of the Four Masters. These in turn were read and utilized by later masters, by Hugh Borgognoni, Theodoric and Bruno of Calabria, and thus passed on to Lanfranc and Guy de Chauliac. The *Surgery* of Roger became indeed, as Guido hoped, the steady foundation of modern surgery; and yet itself remains only a relic of the past, a half-forgotten volume in the long record of human progress.

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MAMMARY CANCER WITH GENERALIZED TELANGIECTATIC CARCINOMA ('CARCINOMA ERYSIPELATODES')

By E. K. DAWSON and J. J. M. SHAW, Edinburgh

INTRODUCTION

Knowledge of the path and extent of tumour-cell dissemination is essential in determining the range and type of treatment required. In many conditions, the existence of dissemination may be difficult to determine; less frequently, the area of dissemination may be more obvious than the primary site, and in a skin lesion may be so arresting in its surface appearance that the original focus is overlooked.

Extensive skin lesions have been observed in association with primary malignant growth in the stomach, intestine, pancreas, kidney, bladder, lung, œsophagus, and, less frequently, ovary and uterus (Willis). Widespread cutaneous involvement may also be found in cuirass cancer and in Paget's disease of the nipple, both conditions usually associated with an underlying mammary carcinoma. It is, however, most strikingly illustrated by the disease which has been variously described as carcinoma erysipelatodes, erysipelas carcinomatosum, carcinoma telangiectaticum, malignant lymphangitis, inflammatory cancer, or miliary carcinosis. It is rather extraordinary to find that in all the recorded examples of this condition the primary malignant tumour was apparently in the breast, but the characteristic picture of reddened erysipelas-like skin, the frequent error in clinical diagnosis, the extensive and progressive cutaneous involvement, and, in most cases, the rapidly fatal termination after the patient came under observation, have raised the question whether the condition should be regarded as a clinical and histological entity rather than a late or special manifestation of mammary carcinoma.

The skin condition in these cases may be first observed before treatment, or it may appear after operation. The significant appearance of extensive spreading redness of the skin may also be complicated by effects ascribed to irradiation. In most of the recorded cases, the clinical picture suggested a primary skin disease or an erythema associated with trauma or burning, and was indeed so little indicative of malignancy that the true import of the cutaneous lesion was missed.

The appearance of reddening and induration of the skin has been frequently noticed in association with mammary cancer, and was described by Billroth, Volkmann, and other earlier writers. It does not, however, appear to have been considered as a special form of tumour-cell dissemination, and no distinctive name was assigned it. The actual frequency of the skin condition cannot therefore be estimated, though in recent years a number of cases have been reported as 'rare' or 'unusual' forms of malignant disease. In a series of 28 cases of mammary cancer reported by Lee and Tannenbaum (1922) as inflammatory carcinoma, the erysipelatous involvement of the skin was a prominent feature, and though they consider the same condition to have been variously described as acute cancer,

mastitis carcinomatosa, lactation cancer, etc., which, in our experience, do not necessarily show a reddened skin, it is probable that most if not all their cases fall into this 'erysipelatodes' group. No special name was given to this appearance until Küttner (1924) described three cases as erysipelas carcinomatosum. Rasch (1931), describing the first case reported in Denmark, preferred the term carcinoma erysipelatodes acutum. Fischer reported five similar cases between 1926 and 1931 as subepidermoidal carcinoma, while Parkes Weber (1935) described a case as carcinoma telangiectaticum, on the ground that there was no real resemblance to erysipelas. Pfahler (1936) had called the condition malignant lymphangitis until Küttner's term was adopted.

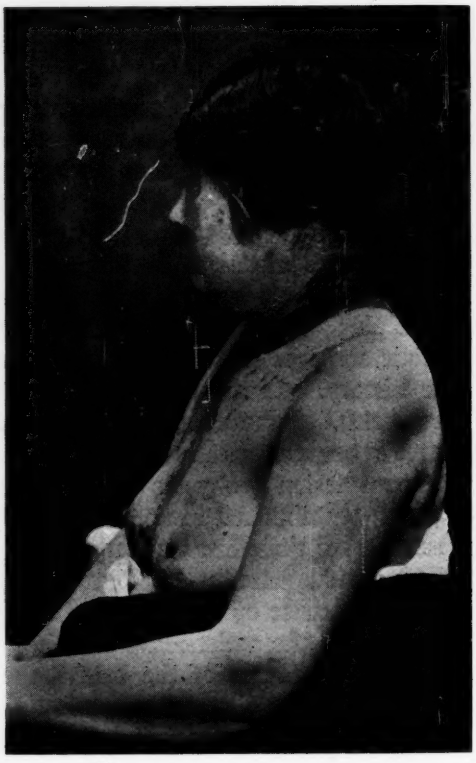
It is probable that numerous cases have been observed, especially, as Pfahler remarks, by dermatologists, but their identification in the literature is difficult because of the varying descriptive terms under which they have been reported. We have collected about 80 reported cases which, from their clinical descriptions, apparently fall into the group under consideration, though comparatively few were actually reported as 'erysipelatous' types of tumour.

The details given, and in particular the histological descriptions, are usually meagre. In some cases no tissue was examined; in others only biopsy material was available; no autopsy investigation is described. Some cases were considered inoperable; others were treated by radical excision or were irradiated, with or without surgery. A number were reported soon after examination and show no later history. One was associated with pregnancy (Fordyce), one with lactation (Gronwald). Some were rapidly fatal, while others were recurrent cases, with long intervals between treatment of the primary tumour and the appearance of the cutaneous lesion (10 years in Nicholas's case and 4 years in one of Pfahler's). Autopsy was obtained in apparently only four of this collected series. The details presented are therefore inadequate for any useful comparison, but some important points are suggested: (*a*) The frequent, if not indeed usual, error in clinical diagnosis because of the skin condition; (*b*) The advanced stage of the malignant process when the patient first exhibited the skin lesion, as evidenced by the diffuse swelling or hardness of the breast, the extensive axillary or cervical adenopathy, and the frequent bilateral mammary involvement; and (*c*) The effect of trauma, in a number of the cases, in localizing and making visible a malignant growth which, from the histological findings, was probably already disseminating itself by the blood-stream.

During the last four years, in a routine investigation of over 400 cases of mammary carcinoma treated in the Edinburgh Royal Infirmary and followed by the Tumour Service of the hospital, we have found 8 cases which fall into this erysipelatous group. The ages range from 38 to 73. All were advanced cases with extensive adenopathy when first examined, and 3 developed bilateral mammary tumours. No case was associated with pregnancy or lactation. The true import of the skin affection was missed in 3 cases. Death occurred within seven months of the first symptom noticed in 4 instances, while another, with bilateral tumour, is going downhill rapidly, with extensive pulmonary metastases. One is a very recent case. Of these 8 cases, the following appears worthy of record, as it provided opportunity to observe the progressive clinical picture and to examine biopsy and autopsy tissue in greater detail than is presented in any previously reported instance.

CLINICAL HISTORY

In September, 1931, the patient, a married woman of 47 years, had an attack of " neuralgic pain on the left side of the neck after sitting in a draught." A relative applied some ordinary mustard on a warm flannel, leaving it on for a total period of 9½ hours. On removal next morning, it was noted that the area showed marked reddening but no blistering; the pain had disappeared and no special attention was paid to the reddened area, in which the colour very slowly grew less vivid. Three months later (December, 1931) some small deep-purplish raised areas

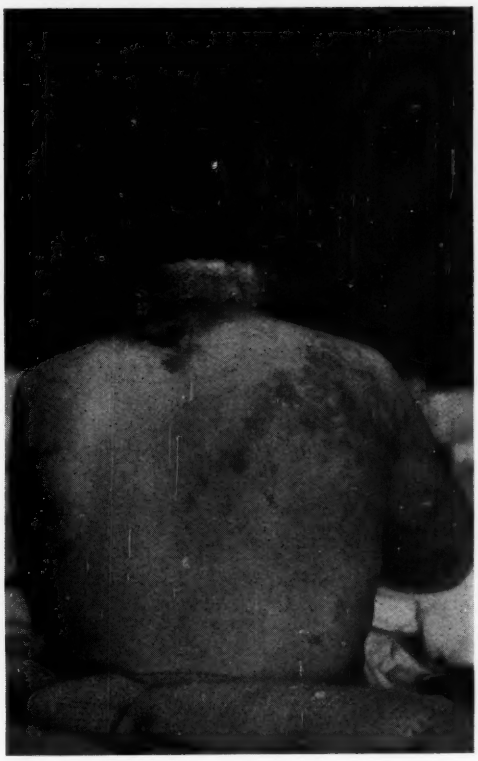


FIGS. 55, 56.—Clinical appearance when first examined, September, 1932.

appeared near the centre of the reddened zone, and a few months after, the whole of the original site of mustard application had become raised above the level of the surrounding skin and showed some forward and backward extension of the condition. Eight months afterwards (August, 1932) similar small reddish patches appeared on both breasts, first on the right side, with some bilateral mammary swelling and slight pain. A month later, the right arm became swollen and the patient noticed lumps in the right axilla and above the right clavicle. Her doctor was then consulted—this was twelve months after the initial pain and plaster—and the patient sent at once to hospital.

On admission, a differential blood-cell count and various chemical tests showed nothing abnormal. A small area of skin from the neck lesion and a lymph-node from the right axilla were excised for histological examination, and reported as suggesting

a primary squamous-cell carcinoma, with extensive malignant spread within blood- and lymph-vessels of the skin and malignant invasion of the lymph-node by a similar type of growth. The question therefore arose whether the skin condition was the primary tumour, or whether the cutaneous lesions were metastatic deposits from a hidden primary source such as the pharynx, œsophagus, or, more probably, cervix uteri, though careful examination failed to reveal any such distant focus. The patient, who was still in apparently robust health, with no loss of weight, no cardiovascular or respiratory upset, and no raised temperature at this or any



FIGS. 57, 58.—Clinical appearance, April, 1933.

subsequent stage, was transferred to the Beechmount annexe of the hospital for irradiation and observation. The case was shown by one of us (J. J. M. S.) at a meeting of the Edinburgh Medico-chirurgical Society in November, 1932, when the grave prognosis associated with malignant invasion of the blood-stream was emphasized.

On admission to Beechmount, the skin showed red raised areas, with papules, varying in size and shape and colour from bright red to purplish, on the face, left side of neck, front of chest, and over both breasts. The largest area, the initial lesion on the neck, showed a raised indurated plaque, dark red to plum colour with black spots. The right breast was uniformly enlarged and œdematous but with no palpable lump; the right arm was also œdematous and showed small subcutaneous nodules. The left arm was less affected (*Figs.* 55, 56).

The effect of surface radium was tested on an area below the right clavicle towards the midline. This was locally effective, and was repeated on an area on the left shoulder. Meanwhile, the skin involvement elsewhere was spreading. Redness and swelling of the right upper eyelid went on to nodule formation, and the subcutaneous tumour deposits in the right arm became more numerous, larger, and harder. Early in January, 1933, the patient complained of an irritating cough, and examination showed impaired percussion note with faint breath-sounds, but no localized lesion in the lungs. At the end of January the patient went home at her own request, but a month later, as more nodules continued to appear on the right arm, with increased swelling and pain, she was re-admitted to hospital, a strip of skin was excised from the back of the arm to relieve the œdema, and some X-irradiation given. This had a markedly toxic effect. When admitted the third time (April, 1933), she was obviously going downhill (*Figs.* 57, 58). The nodules in the right arm had fused to form a generalized induration, and though the actual reddening of the skin had not spread much, numerous subcutaneous deposits were apparent in other areas. There was still no localized chest lesion or definite clinical sign of other internal metastases. Nine days after admission the patient showed sign of mental upset, and died suddenly, early in May, 1933, a year and eight months after the first indication of trouble.

AUTOPSY EXAMINATION

Autopsy was performed by Dr. James Davidson. The following notes are abridged from his descriptions.

GENERAL APPEARANCES.—The body was that of a normally developed moderately-nourished female, showing obvious loss of weight. No jaundice was present; there was marked œdema of the right arm and both lower limbs.

SKIN.—The skin of the face suggested an ante-mortem erythematous condition, associated with extensive subcutaneous malignant growth. This involved both sides of the face, with extension to the back of the right ear, the back of both shoulders, the neck, and, at an early

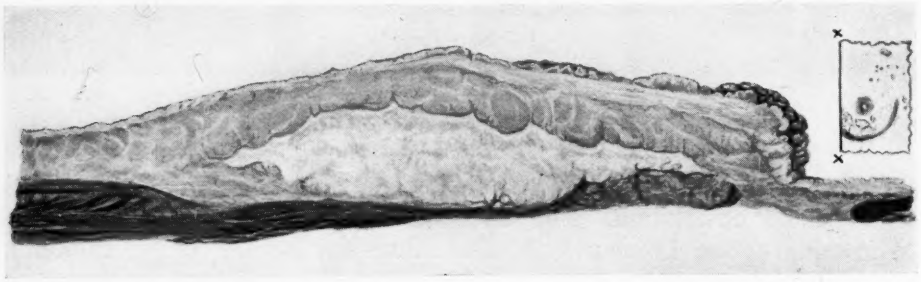


FIG. 59.—Tumour in right breast (primary growth); tissue sectioned 1 in. lateral to nipple plane (X—X), showing fixation to deep muscle and nodular invasion of subepidermal tissue. ($\times \frac{3}{8}$.)

stage, the left upper arm. The right arm was grossly swollen and indurated, with malignant involvement of its whole extent, especially noticeable near the elbow. The left arm was also indurated near the elbow. The upper part of the front of the chest was similarly affected; there was a small whitish area where radium had been applied. Numerous subcutaneous nodules, 1 to 2 cm. in diameter, were present below the right breast and extended to the right axilla.

BREASTS.—The *right breast* was considerably enlarged, with extensive malignant involvement and induration of the skin and a raw hæmorrhagic patch near the nipple. The *left breast* was less affected, but the medial half was indurated and the overlying skin deep in colour.

On section, definite hard masses were found in the lower quadrant of the right breast (*Fig.* 59); the left also had hard pale areas. The right pectoral muscles were extensively invaded with diffuse tumour growth; the left muscles were free.

VISCERA.—The *pleural sacs* contained a little fluid. On the right side the *parietal pleura* showed tumour growth in lymph-vessels along the line of the ribs; the *visceral pleura* had pale streaks and pin-point nodules of subpleural malignant invasion. In the *right lung* were found pin-point greyish miliary nodules, with peribronchial and perivascular extension. The *left lung* and *pleura* gave no evidence of invasion.

The *pericardial sac* was obliterated by adhesions, recent in character; the external surface of the parietal pericardium showed small greyish areas of malignant growth. The *heart* was not enlarged. The right ventricle had a small subepicardial tumour nodule on the posterior wall. No heart muscle invasion was noted; the valves, coronary vessels, and aorta were unaffected.

The *glottis* showed marked œdema and apparent malignant involvement; the mucosa of the *trachea* was somewhat congested. Numerous flat discrete subepithelial nodules were noted in the *œsophagus*.

The *stomach* showed some small subserous malignant nodules near the greater curvature; the mucosa gave no evidence of tumour, ulceration, or hæmorrhage. The rest of the alimentary tract showed nothing abnormal.

The *liver* was of average size, with a smooth surface; at the base of the right lobe were small pale subcapsular areas suggestive of malignant growth. On section, the liver tissue showed chronic venous congestion; there was no gross tumour involvement, but pin-point areas of apparent malignant growth.

The *gall-bladder* showed subserous tumour tissue near the cystic duct, which was also invaded, with malignant extension into the liver substance.

The *pancreas* had numerous pin-point white nodules scattered over its surface; none were evident on section.

Blood-stained material was lying in both renal pelves, but no evidence of tumour was found in *either kidney*. The *suprarenal glands* were somewhat enlarged and firm, and suggested malignant invasion.

A large nodule was seen in the wall of the *urinary bladder*.

The *uterus* and *ovaries* gave no evidence of tumour growth; a small deep-lying nodule of malignant tissue was found in the anterior wall of the *vagina*.

Some areas of the *pia-arachnoid* showed pin-point nodules; the cerebral tissues showed œdema only.

BONES.—The bones examined (femur and lumbar vertebræ) showed no obvious malignant invasion.

LYMPH-NODES.—There was enlargement and malignant invasion of lymph-nodes in both axillæ, both cervical regions, mediastinum, root of both lungs, hilum of liver, greater and lesser curvatures of stomach, mesentery, both inguinal regions, hilum of right kidney, and the para-aortic abdominal area. Where both sides were involved, malignant growth affected the right side to a greater extent.

Examination thus showed tumour growth in both breasts, right pectoral muscles, right lung and pleura, peri- and epi-cardium, larynx and œsophagus, gastric serosa, liver, gall-bladder, pancreas, both suprarenal glands, urinary bladder, vagina, pia-arachnoid, and lymph-nodes in numerous areas. There was also, as the most striking feature, very extensive involvement of much of the skin of the thorax, face, and upper limbs. The left lung and pleura, the spleen, kidneys, uterus, ovaries, cerebral tissues, and bones (femur and lumbar vertebræ) were not obviously invaded.

HISTOLOGICAL EXAMINATION

The tissues removed in November, 1932, from neck and axilla for diagnostic purposes, and in March, 1933, from the back of the right arm, were examined by us, together with the autopsy material.

Biopsy Tissue.—

THE SKIN FROM THE NECK.—The hæmangioma-like area of skin from the neck —the site of the mustard application—showed, in the nodule examined, greatly dilated vessels below a thinned and bulging epidermis (*Fig.* 60). These vessels

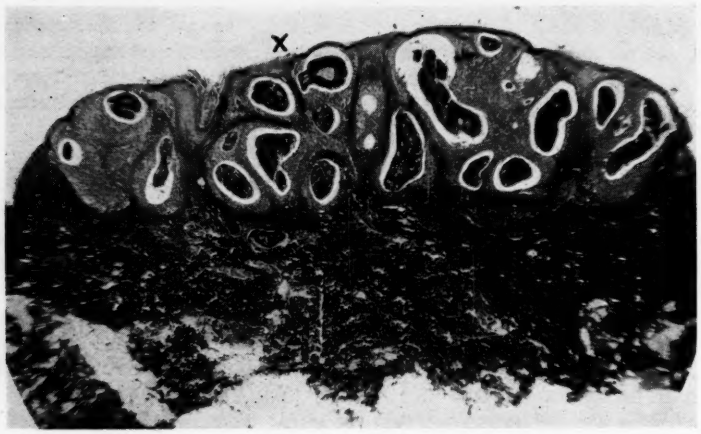


FIG. 60.—Nodule from neck lesion, with dilated blood-vessels containing tumour cells. X, Area enlarged in *Fig.* 62. (× 15.)

contained masses of tumour cells, mixed with blood-cells, mainly erythrocytes, and, from their anatomical distribution and contents, are considered branches of the

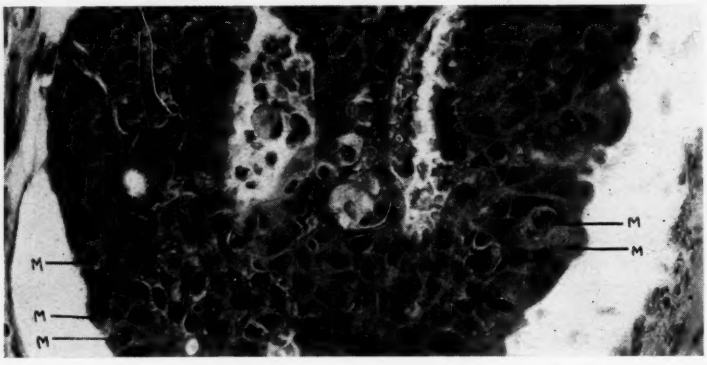


FIG. 61.—Squamoid type of tumour cell in a blood-vessel from nodule of *Fig.* 60. M, Mitosis. (× 320.)

terminal blood-capillary loops of the skin papillæ. The tumour cells showed degeneration in some of the vessels; in others mitotic figures were numerous (*Fig.* 61). The type of cell is squamoid rather than squamous (*Figs.* 61, 62), and does not, in our opinion, necessarily point to an epidermoid primary growth, as squamoid cells

are a not infrequent finding in both primary and metastatic tissue in mammary tumour. The invaded vessels were surrounded by a cellular zone consisting of

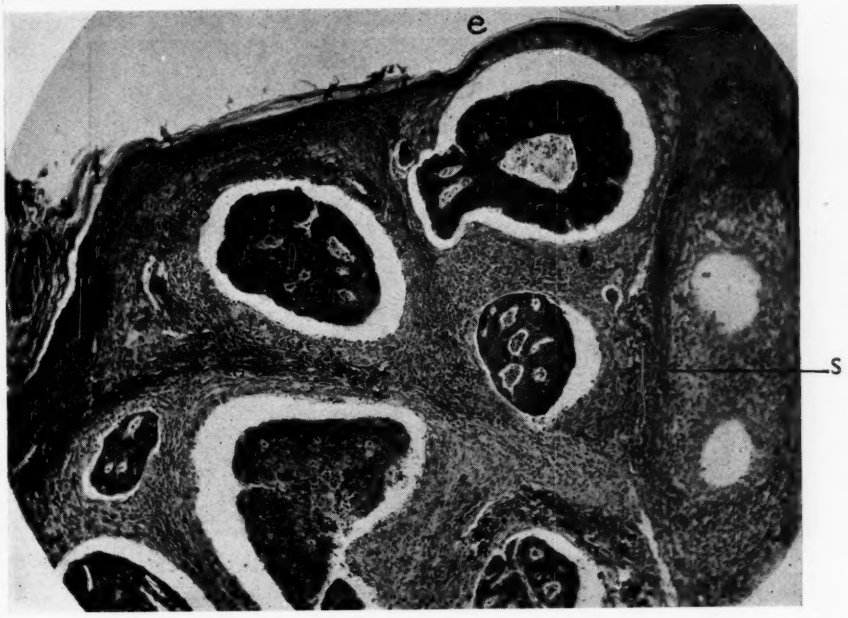


FIG. 62.—Area X in *Fig.* 60, showing thinned epidermis over a distended tumour-filled vessel (e) and perivascular stroma proliferation (S). Cf. *Fig.* 63. (× 70.)

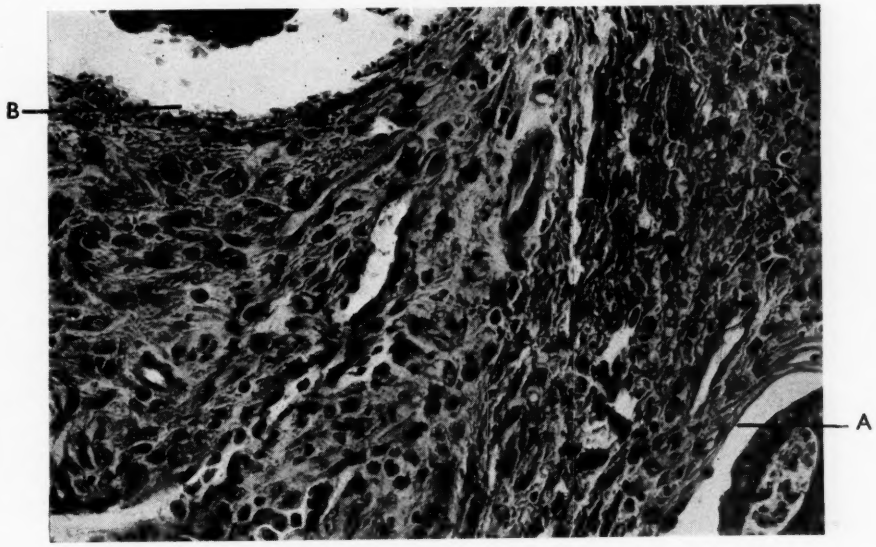


FIG. 63.—Active granulation tissue around tumour-filled capillaries in neck nodule. A, Capillary wall intact; B, Wall ruptured. (× 320.)

active granulation tissue, with numerous fine capillaries, pigmented macrophages laden with hæmosiderin associated with small interstitial hæmorrhages, and a moderate infiltration with lymphocytes and plasma cells (*Figs.* 62, 63). Some

of the vessels showed few tumour cells and a narrowed lumen surrounded by a broader reaction zone, an appearance which suggested rupture of the dilated vessel and subsequent destruction of the malignant cells by stroma proliferation. This

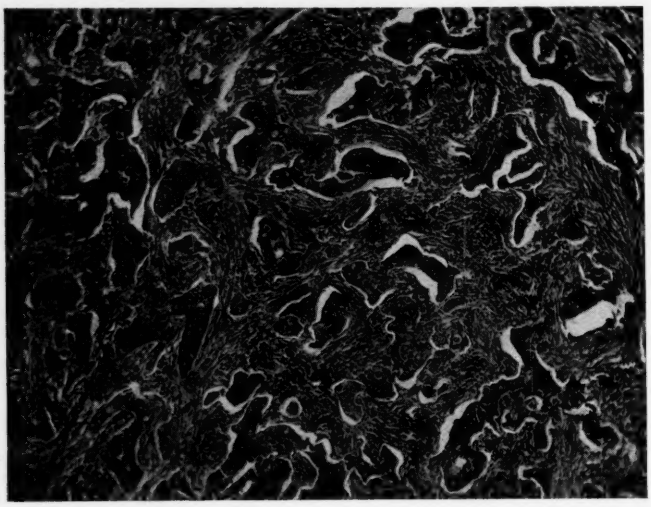


FIG. 64.—Squamoid-cell tumour growth in axillary lymph-node, with dense fibrous tissue. (× 70.)

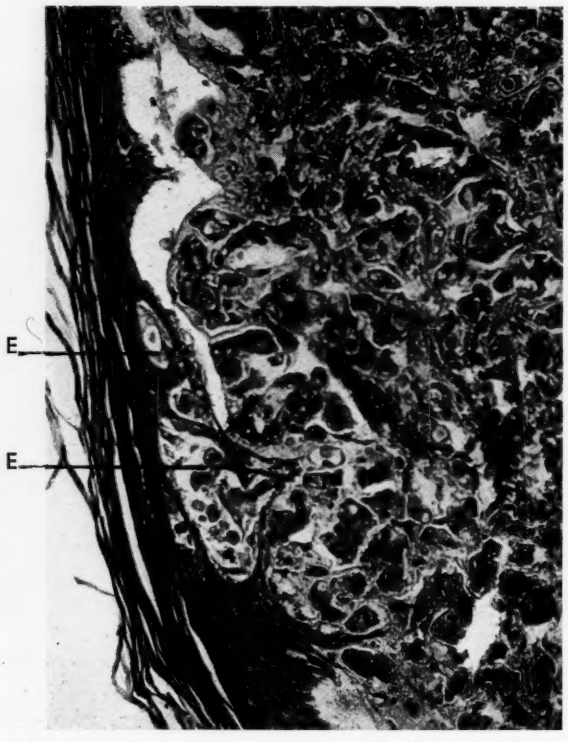


FIG. 65.—Second biopsy tissue, from right arm, showing diffuse tumour growth, with invasion of epidermis (E). (× 320.)

may explain the paling of the central parts of the reddened skin area described by various observers of this condition and apparent in our case, where the reddening first noticed in the neck gradually became less vivid. No thrombosis was observed in these invaded capillaries. The integrity of the endothelial cell-lining varied; it was intact in the less dilated vessels (*Fig.* 63, A), but had disappeared in the more distended which had ruptured (*Fig.* 63, B). The skin below the superficial (papillary) level showed no invasion by tumour (*Fig.* 60).

THE AXILLARY LYMPH-NODE.—The lymphoid tissue was almost completely replaced by malignant growth of a similar squamoid cell type, accompanied by dense fibrous tissue (*Fig.* 64).

THE SECOND BIOPSY TISSUE.—This material, removed from the right arm four months later, showed a much more advanced malignant invasion of the skin. A tumour nodule, consisting of greatly thickened infiltrated skin, extended from the subcutaneous fat to the epidermis, which was itself invaded and showed some keratosis (*Fig.* 65). Lymph- and blood-vessels were extensively invaded beyond this nodule area, and other small nodules had formed in the underlying fat.

Autopsy Tissue.—Over 60 sections were prepared from the skin and other invaded tissues.

SKIN.—The microscopical picture varied considerably in the areas examined from neck, arms, and thorax. Some areas showed multiple small nodules of dilated, tumour-filled capillaries surrounded by granulation tissue, without involvement of the deeper skin layers, similar to the first biopsy picture; other nodules, apparently

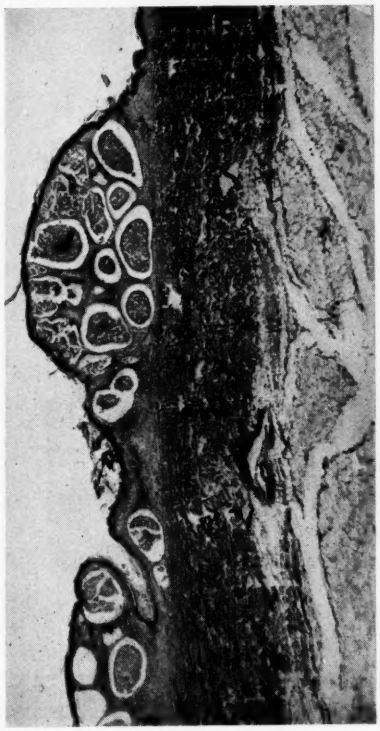


FIG. 66.—Multiple small nodules under the epidermis, at an early stage. (× 12.)

FIG. 67.—Area of thickened skin with diffuse tumour invasion. B.V, Blood-vessel with tumour cells. (× 12.)

an earlier stage of dermal invasion, showed little peri-capillary stroma proliferation (*Figs.* 66, 70); in others more advanced, hæmorrhages and fibrosing perivascular connective tissue had caused partial or complete destruction and disappearance of

FIG. 68.—Skin from neck, with invaded lymph- and blood-vessels. P, Platysma muscle, also invaded (cf. *Fig.* 69). (× 12.)

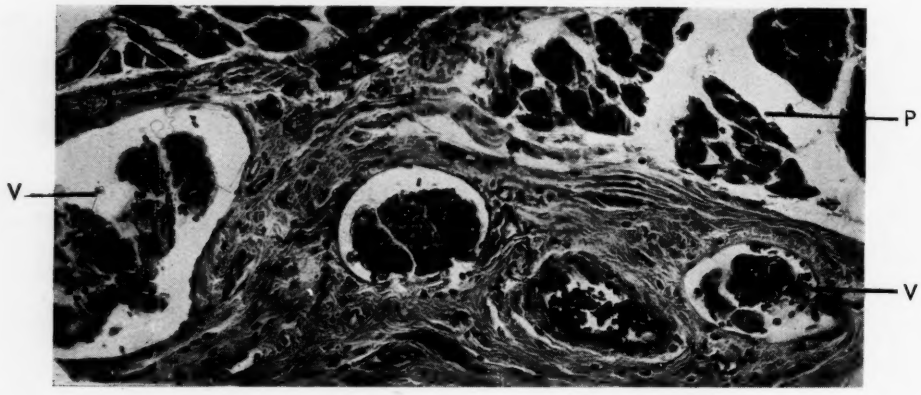


FIG. 69.—Platysma muscle (P), with invasion of small veins (V). (Cf. *Fig.* 68, P.) (× 180.)

both tumour and blood cells from the lumen. Thrombosis was rarely observed, and only in the larger vessels deeper in the skin. In some areas the entire depth of the skin was involved in tumour growth, with connective tissue as well as lymph- and blood-vessels showing extensive invasion; other similar areas were associated with great thickening of the cutis, an appearance suggestive of active malignant

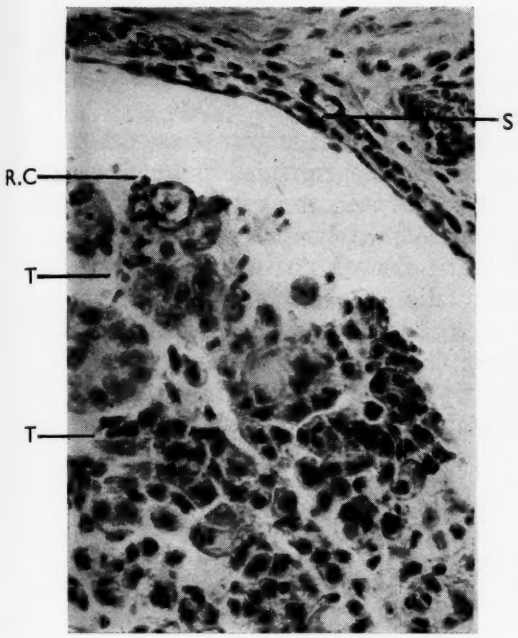


FIG. 70.—Invaded blood-vessel, showing varied tumour cell type (T) and little perivascular activity (S). R.C, Red blood-cells. (× 300.)

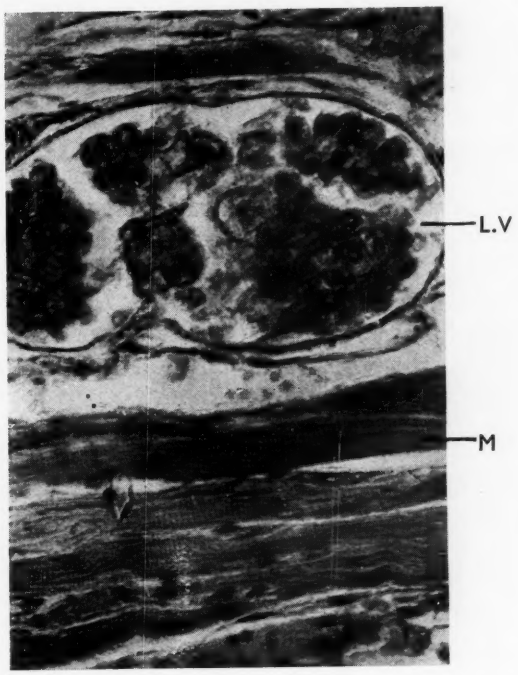


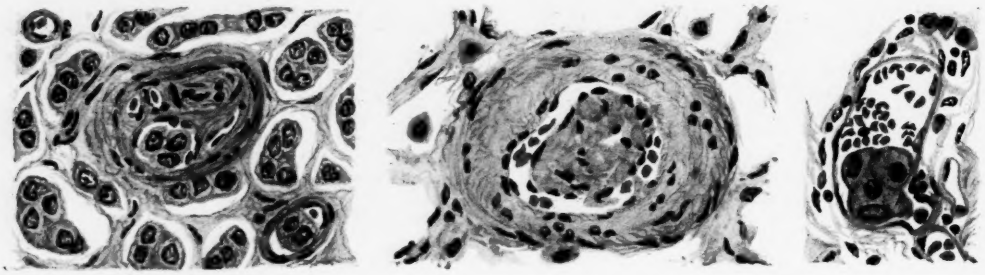
FIG. 71.—Right pectoral muscle (M) with invaded lymph-vessel (L.V). (× 400.)

FIG. 72.—Right lung, under the pleura, showing invaded lymph-vessels (L.V), veins (V), and arteries (A). (× 100.)

cell proliferation accompanied by fibroblastic activity (*Fig.* 67). Skin from the neck removed with the underlying platysma muscle showed invasion of lymph-vessels and veins in the muscle substance as well as involvement of the skin itself to the epidermis (*Figs.* 68, 69). The tumour cells in the distended blood-vessels varied greatly in type and apparent vitality (*Fig.* 70).

BREASTS.—The *right breast* showed the genesis of tumour growth as malignant intraductal cell proliferation in numerous small ducts surrounded by much elastic tissue, in addition to extensive invasion of the corpus mammæ, partly as generalized infiltration, partly as small nodular formations. Small lymph-vessels, capillaries, and arteries were also invaded. The *left breast* showed no tumour genesis, but extensive malignant spread, considered metastatic in character, in the form of many small nodules of infiltrated stroma. The *right pectoral muscles* showed small nodules in addition to invaded lymph-vessels (*Fig.* 71) and blood-vessels.

VISCERA.—The *visceral pleura* on the right side showed numerous small malignant nodules, which suggested proliferation in and subsequent spread around perivascular lymph-vessels. In the *right lung* itself, there was extensive tumour



a *b* *c*

FIG. 73.—Small invaded pulmonary blood-vessels (right lung) showing: (*a*) Re-canalization; (*b*) Hyalinization; (*c*) Embolus of active tumour cells, with intact erythrocytes. (× 300.)

growth in practically every lymph-vessel, peribronchial and perivascular, as well as invasion of numerous large and small blood-vessels (*Fig.* 72). The small blood-vessels showed various stages of thrombosis, with re-canalization or hyalinization (*Fig.* 73, *a* and *b*). Some interalveolar capillaries contained emboli of apparently active tumour cells surrounded by intact red blood-cells (*Fig.* 73, *c*).

The *thyroid gland* showed no malignant nodules, but nearly all the venous channels, large and small, were dilated by masses of tumour cells mixed with red blood-cells. Numerous lymph-vessels were also invaded, and scattered emboli were observed in the arteries.

The *larynx* and *trachea*, sectioned at several levels, showed no actual nodules, but extensive invasion of lymph- and blood-vessels in the mucous membrane and deeper tissues (*Fig.* 74). The fibrous septa in the extrinsic muscles contained tumour-filled lymph-vessels. The *œsophagus* showed a similar involvement of the mucous membrane, with beginning ulceration.

A nodule in the *epicardium* showed a localized area of malignant invasion of small lymph-vessels and surrounding connective tissue as well as tumour cells in a blood-vessel (*Fig.* 75), apparently a distended vein; the cardiac muscle itself was not involved.

No nodules were found in the *liver substance* or *capsule* in the sections examined, but emboli of tumour cells were observed in some of the widely dilated congested branches of the portal vein. There was also marked venous congestion round the central veins, with extensive peri-portal fatty infiltration of the liver cells.

The *pancreas* showed small nodules and areas of more generalized malignant cell infiltration in addition to massive invasion of blood- and lymph-vessels. The veins were, in general, much dilated with tumour and blood cells, and small emboli were also found in arteries.

No malignant growth was found in the *spleen*, *bone-marrow*, or *kidneys*.

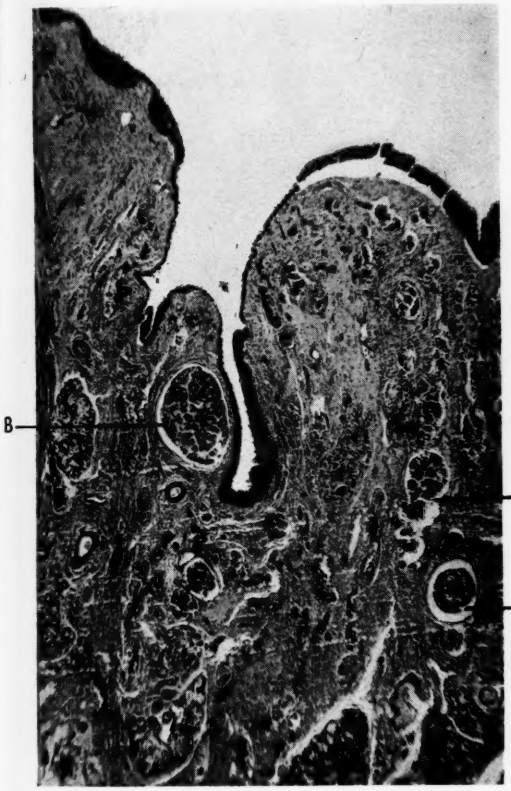


FIG. 74.—Larynx at level of vocal cords, with invaded lymph- and blood-vessels (L, B). (× 25.)

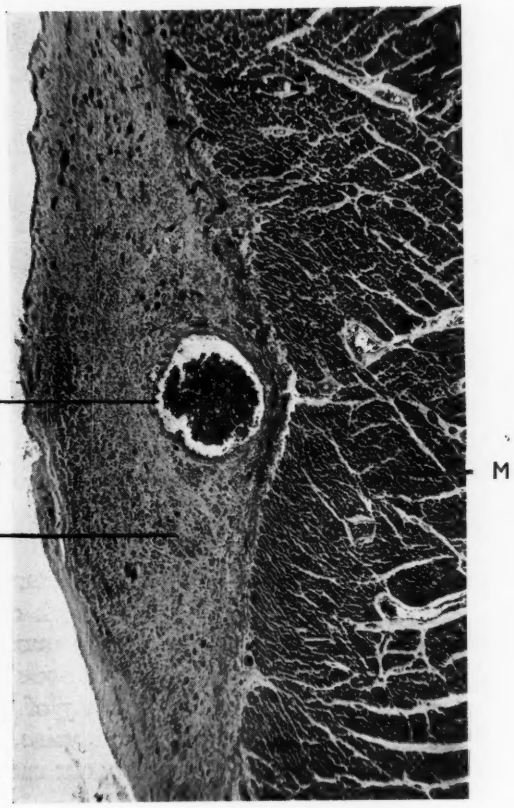


FIG. 75.—Epicardium with tumour nodule, showing invaded blood-vessel (V) and connective-tissue infiltration (C.T). M, Cardiac muscle. (× 25.)

The *suprarenal glands* showed the central vein and sinusoidal venules of the medulla extensively invaded by tumour cells (*Fig.* 76); veins and arteries in the capsule were also involved.

A section of the *vaginal wall*, which did not include the macroscopic nodule, showed groups of tumour cells in the smaller blood-vessels under the squamous epithelium.

Sections of the *meninges* did not include a malignant nodule area; the underlying brain substance contained no tumour cells.

LYMPH-NODES.—All the nodes examined showed loss of normal architecture due to extensive replacement of lymphoid tissue by malignant growth. The bronchial

nodes were almost completely replaced by tumour; the fatty tissue surrounding them was much infiltrated, and showed small nodules as well as invaded afferent and efferent lymph-channels. Veins and a few small arteries were also involved outside the capsule, and some intracapsular areas suggested that tumour cells had broken into small blood-vessels.

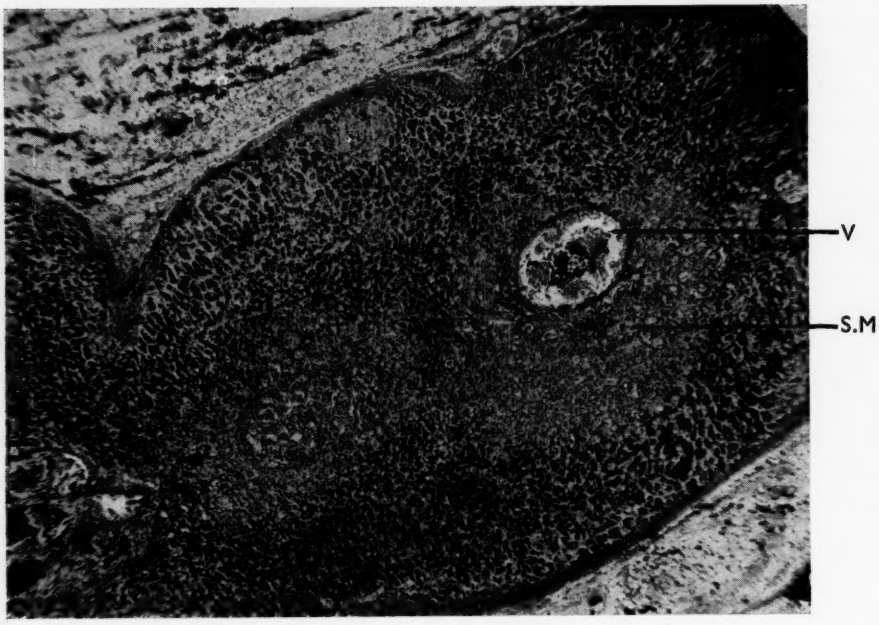


FIG. 76.—Suprarenal gland, with invasion of central vein (V) and sinusoidal venules of medulla (S.M). (× 25.)

Summary.—Histological examination showed bilateral mammary tumour, primary in the right breast, with extension of the malignant process by invasion of lymph- and blood-vessels in numerous organs, serous surfaces, muscles, and, in particular, the skin. Discrete nodule formation or more generalized tissue infiltration was also observed in many of the invaded areas. Lymph- and blood-vessels, especially the capillaries and veins, were, in general, dilated as well as involved in tumour spread, and justify our use of the descriptive term *generalized telangiectatic carcinoma*.

DISCUSSION

Malignant disease with reddened erysipelas-like skin is considered by some recent observers a distinct pathological entity, but many cases are found in the literature, especially the older literature, where gross examples of disease are illustrated, without any special nomenclature or emphasis on the skin discoloration. The skin condition, though very characteristic in exaggerated cases, with extensive "flaming redness", shows many variations in the extent, colour, rate of spread, and form of the cutaneous involvement. The redness would appear, indeed, to be more or less fortuitous and is not associated with any one definite microscopical picture. Its presence, however, apparently always points to extensive malignant involvement of the cutis, whether lymph-vessels, blood-vessels, or stroma, or all

of these, be invaded. Such cutaneous invasion may occur in any mammary cancer. It is well exemplified in cuirass cancer, which may or may not show reddening of the skin, and in malignancy associated with Paget's disease of the nipple, as well as in the 'erysipelatodes' group. There seems little justification for regarding the extending cutaneous malignant process, when accompanied by reddening, as the distinct pathological entity suggested by such terms as carcinoma erysipelatodes, subepidermal mammary cancer, inflammatory carcinoma, etc.

The importance of the skin appearance, apart from its association with advanced malignancy, lies in its clinical resemblance to primary skin affections such as erysipelas, mycosis, etc., or mammary inflammation, a resemblance which has frequently led to error in diagnosis and treatment.

It is significant that, in many reported cases, as in ours, the skin redness appeared after definite trauma, interpreting this term in the wide sense of any injury to the tissues (sunburn, surgical incision, irradiation erythema, etc.). There is no evidence of causal connection between trauma and carcinoma in any of these cases; in all, malignant disease was already present, and in many had probably already extensively invaded the skin. Trauma caused localization and proliferation of tumour cells in the injured inflamed area, and thus revealed the underlying malignancy.

As far as it may be interpreted from the advanced post-mortem picture, the sequence of tumour spread in our case was as follows. The primary growth in the right breast spread by the lymph path to involve the axillary and cervical lymph-nodes and the other breast. Extensive intrathoracic growth on the right side suggests that, simultaneously or subsequently, tumour cells spread by deep lymph-channels through the pectoral and intercostal muscles to the retrosternal nodes and the pleura, with further peribronchial and perivascular lymphatic extension in the lung. This lymphatic type of spread is everywhere evident, and affected not only the lung and numerous other organs, but lymph-nodes in all areas from the cervical to the inguinal regions.

The time and site of initial invasion of the blood-stream is less obvious. There are several possibilities: (*a*) Tumour cells may have entered the systemic circulation from the lymph-stream by way of the thoracic duct, right heart, and pulmonary vessels; (*b*) The blood-stream may have been invaded primarily in the mammary tissues or in some other organ; (*c*) In view of the extensive pleural and pulmonary involvement, it is possible that invasion of the blood-stream occurred mainly in these tissues, the tumour cells passing through pulmonary veins direct to the left heart and thus into the arterial circulation. The proliferation of tumour cells in the capillaries of the skin papillæ, without invasion of the deeper dermal layers in the early stages of nodule formation (*see Fig.* 66), points to arterial embolism; the admixture of active and degenerating cells in these vessels (*see Fig.* 70) suggests continuous repetition of the embolic process. Reddening of the skin may have resulted from the vaso-dilatation associated with capillary embolism and stasis. Telangiectasis produced by trauma would facilitate this terminal lodgement and proliferation of tumour cells in the skin.

SUMMARY AND CONCLUSIONS

A case of mammary cancer of 'erysipelatodes' type is reported. The malignant condition, first apparent as a large reddened hæmangioma-like area in the neck associated with trauma, spread to involve much of the thoracic wall, arms, and

face, with the formation of multiple subcutaneous nodules, further reddened areas, and small ulcerations. Numerous internal metastases were found at autopsy.

A comparison of the recorded erysipelatous cases with this one suggests that the condition is a late stage of malignant mammary tumour with cutaneous carcinosis, which may, in some cases, be associated with more typical forms of cuirass cancer or with Paget's disease of the nipple.

The histological interest of this case lies mainly in its illustration of two simultaneous methods of tumour dissemination—(*a*) wide-spread lymph-vessel carcinosis in skin, numerous internal organs, and, in particular, pleura and lung, and (*b*) blood-vessel invasion in all metastatic areas, including the skin, with dilatation and stasis, i.e., generalized telangiectatic carcinoma. The association of massive lymph- and blood-vessel invasion in pleura and lung with thrombosis of the smaller blood-channels suggests that the systemic malignant spread may have occurred mainly by tumour cells gaining direct access to pulmonary veins and the left heart without intermediate passage through alveolar capillaries.

The photographic work and the preparation of the tissue have been carried out at the Research Laboratory of the Royal College of Physicians, the Surgical Research Department of the University, and the Royal Infirmary, Edinburgh.

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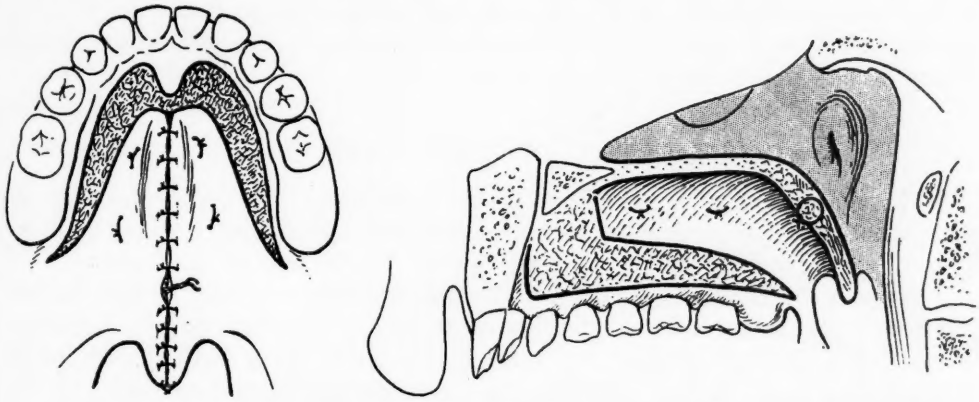
THE TECHNIQUE OF OPERATION FOR CLEFT PALATE

By W. E. M. WARDILL, Newcastle-upon-Tyne

In the following paper an attempt is made to deal with the surgical technique of operation for cleft palate as practised by myself at present. It is not claimed that finality has been reached, but the methods, as outlined, have proved so eminently satisfactory that it is felt well worth while to record them.

Since the war there have been many advances in the surgical treatment of cleft palate, and foremost amongst those who have been responsible for this must be mentioned Dr. Victor Veau, who showed that raw surfaces should always be covered, as far as possible, and that any areas necessarily left raw should be over parts not concerned with the movement of the soft palate. Again, Veau pointed out that if an operation of the Langenbeck type is carried out, the sutured flaps are prevented from adhering to the underlying bone of the hard palate, thus



Figs. 77, 78.—The Veau flaps were designed to allow the palate to ascend and re-attach themselves to the bone. Note the length of these flaps. (*Reproduced by kind permission from "Division palatine", by Victor Veau.*)

increasing the liability to contracture or infection. He therefore practised the complete freeing of the hard palate flaps and their resuture in a position where they could obtain adhesion to the bone with occlusion of blind cavities (*Figs.* 77, 78). Some part of the technique of repair of the palate as described below is the direct outcome of having absorbed some of Veau's principles and their adaptation to the problem as seen from another standpoint.

In 1921 Gillies and Kelsey Fry published a method in which they aimed at closing the velum at the expense of the hard palate, which they left open to be occluded by an obturator. They hoped by this means to be able to push the velum closer to the pharyngeal wall, and thus enable nasopharyngeal sphincter action to take place. In 1925 Dorrance produced what he described as a "push-back" operation, designed to push the whole palate backwards.

Early on in my experience in repair of the cleft, I recognized that in order to secure successful closure and a mobile velum the suture line must be free from tension, and with this object in view, I advised section of the hamular processes. Gradually this search for an ideal was carried further and further until now it is recognized that in order to secure successful anatomical and functional closure it is necessary to sacrifice all bony attachments of the soft palate. Recognition of this is by far the most important fact in the repair of the palate.

The operation as described below has the following advantages. Firstly, it enables a complete closure to be obtained at one sitting. Secondly, the pious hope that nasopharyngeal closure can be effected becomes almost a certainty. Thirdly, the operation, with slight modifications, is applicable to all types of cleft. Fourthly, the V Y advancement obtained enables one to secure the greatest possible length of velum without any artificial juggling with the uvula or pillars of the fauces. Fifthly, I am able to state quite definitely that if the principles of the operation as described below are practised on infants before the speech age, i.e., before about two years, and a successful closure is obtained, the large majority of these children will learn to speak naturally without any speech training, and will be indistinguishable from normal children. This statement is based upon the experience gained from my own cases and from having seen the work of others who practise the principles as outlined below. Notably amongst these is Mr. T. Pomfret Kilner, who has been kind enough to allow me to review some of his work with him, and who has always acted as a fearless and most helpful critic of all my doings in the surgery of cleft palate.

TECHNIQUE OF THE OPERATION

There are four principal stages in the operation: (1) Preparation for the pharyngoplasty; (2) Preparation of the palatal flaps and freeing from bony structures; (3) Completion of the pharyngoplasty; (4) Suture of the flaps.

Stage 1: Preparation for the Pharyngoplasty.—In 1927 I devised, and first practised, the operation of pharyngoplasty, which was designed to counteract the enormous increase which takes place in all diameters of the nasopharynx in cleft palate, and in this way facilitate closure of the nasopharyngeal valve. It has been described in previous issues of the BRITISH JOURNAL OF SURGERY, but a repetition, with the addition of a few practical points, is not thought to be out of place.

Anæsthesia for these cases is best given by the well-known endotracheal method of Magill, the tube being concealed beneath the tongue-piece of the gag (Dott's modification of the Boyle Davis). In place of the rebreathing bag, Dr. Philip Ayre has devised an open method, described in this issue (p. 131), by which prolonged anæsthesia can be maintained with little or no deterioration in the condition of the child. I commend this method most earnestly to all who are practising cleft-palate or hare-lip surgery.

The head is thrown well back over a low pillow or over the end of the table. Illumination is of great importance, the best being given by a shadowless light, although a headlight, or even a single powerful bulb situated in the right position, will sometimes do. A transverse incision is made through the mucosa and the superficial fibres of the superior constrictor muscle of the pharynx, at the level

where the ridge of Passavant normally forms during pharyngeal muscular movement. This level can be identified either by making the patient gag under light anæsthesia, or by noting the situation of the anterior arch of the atlas, which forms a cushion shortly below the level of the adenoid pad. The incision is best made by a No. 11 or 15 Bard-Parker blade, the hand being steadied by resting on the right cheek. Bleeding rarely gives any trouble, and can be arrested by the pressure of small gauze swabs wrung out of 1–150 carbolic acid solution. The lower edge of the incision is then picked up in long, fine, mouse-toothed dissecting forceps, and a special elevator (really a short aneurysm needle), is introduced between the superior constrictor muscle and its enclosing buccopharyngeal fascia. The point of the elevator is gradually worked downwards and from side to side until a considerable area is undermined, and until its point passes beyond the salpingopharyngeal folds. These are tight fibromuscular bands which lie on the lateral walls of

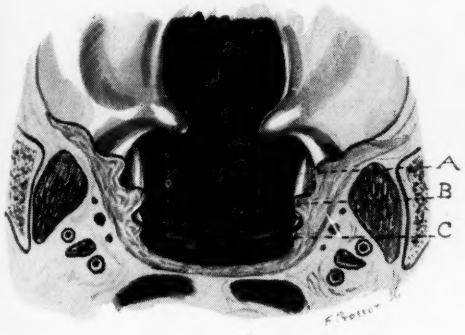


FIG. 79.—Transverse section of the pharynx in a case of cleft palate: A, Anterior pillar of the fauces; B, Posterior pillar; C, Salpingcpharyngeal fold.

FIG. 80.—Pharyngoplasty. The elevator is introduced beneath the edge of the incision, and the mucosa and fibres of the superior constrictor are raised up. The shaded part indicates roughly the area of undermining. The two red lines indicate nicks which are sometimes made to increase the raw area available for suture.

the pharynx, passing in a vertical direction from the bullæ of the Eustachian tubes, and, in their lower parts, lying close behind the posterior pillars of the fauces (*Fig.* 79). During the whole of this process some resistance should be felt to the movement of the elevator; should there be no feeling of resistance, then it usually means that the buccopharyngeal fascia has been perforated and the retropharyngeal connective space has been opened. Having dissected the lower part of the incision, the upper part is now commenced, and the undermining is continued as far as the base of the skull. At this point the elevator is removed and reinserted at the end of the transverse incision, the salpingopharyngeal fold is picked up, and the incision is continued into, but not through, the fold. This is repeated on the other side. Sometimes, when it is thought that the denuded area so provided is insufficient, a small vertical snip is made on the inner side of each salpingopharyngeal fold (*Fig.* 80) to increase the raw area available for suturing.

The process of suturing is now begun, and as the object of this part of the operation is to produce a ridge on the pharyngeal wall, and at the same time narrow the nasopharynx from side to side, the incision is sutured transversely. The most

important point in this connection is to take a big bite of tissue containing the salpingopharyngeal fold, the only really firm supporting structure in the posterior part of the nasopharynx. For this purpose No. 0 or 00 chromic catgut is used and is mounted on a ¾-in., half-curved needle, or on a large Reverdin needle. Suturing is commenced by picking up a large bite of tissue at the very end of the transverse incision, and including the right salpingopharyngeal fold. Where an ordinary curved needle is used it is held by a von Eiselberg or some such needle-holder. It is very important to have a needle-holder with the correct curve, the von Eiselberg having been found to be the best for this purpose. The left-hand end of the incision is now picked up by the needle, and a good bite of the salpingo-pharyngeal fold is once again taken (*Fig.* 81). The catgut is left long and held by an artery forceps, and is not tied until a later stage of the operation. Altogether

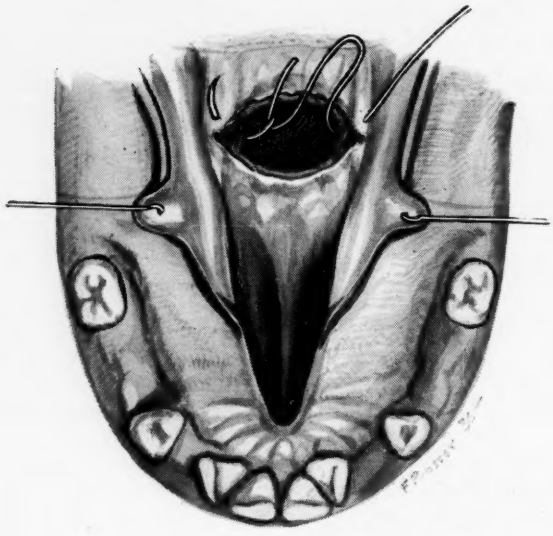


FIG. 81.—The needle is shown passing through the left salpingopharyngeal fold.

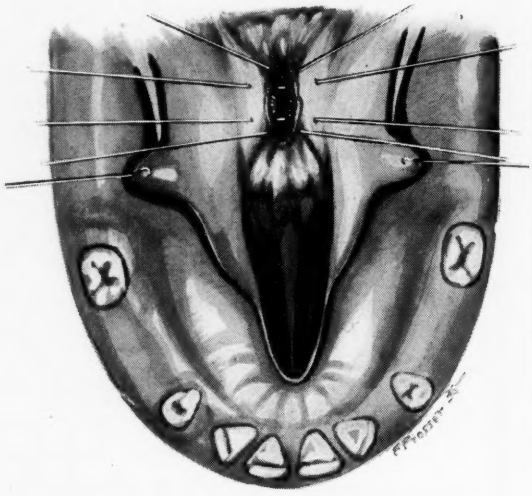


FIG. 82.—Shows the effect of traction upon the sutures and how they tend to narrow the nasopharynx, the salpingopharyngeal folds being dragged together.

four or five sutures are inserted, at least two of them gaining a good hold of the salpingopharyngeal folds, the others being used to unite the cut edges of the central parts of the incision. The operation when completed rarely looks neat, but when the sutures are tied it is seen that there is a marked reduction in the diameters of the nasopharynx (*Fig.* 82).

Stage 2: Preparation and Freeing of the Palatal Flaps.—For the purposes of description it will be assumed that we are to deal with a cleft involving the soft palate and the hard palate as far forwards as the anterior palatine foramen.

To commence, the hamular process is identified by feeling for it with the index finger (*Fig.* 83). An incision is then made on the outer side of this process and is carried along the hard palate, closely hugging the alveolar margin and extending nearly as far as the anterior end of the cleft. Then, inserting an elevator into the posterior end of the incision, the hamulus is identified and broken off (*Fig.* 84). In some cases it may be necessary to use the points of a pair of strong

scissors to carry this out effectively. The importance of division of the hamulus cannot be over-estimated, since, by its destruction, the tendons of the tensores of the palate are released, and one of the greatest obstacles to easy suturing and free

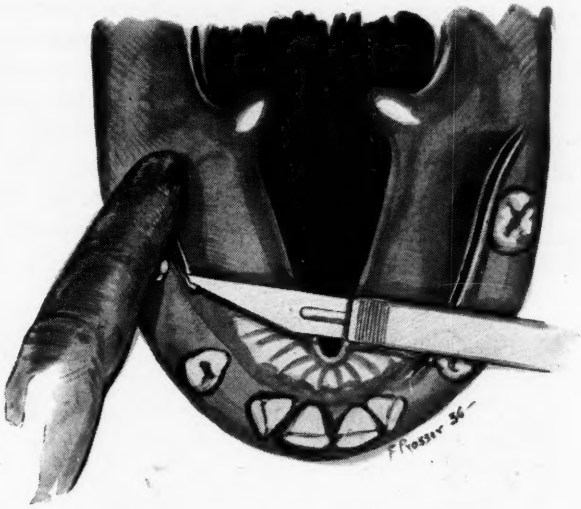


FIG. 83.—The index finger of the left hand identifies the hamular process. The incision commences to its outer side.

mobility is removed. A suitably shaped elevator is then passed into the lateral incision, and the mucoperiosteum of the hard palate is raised along the whole length of the incision. The elevator is then pushed inwards until its tip appears

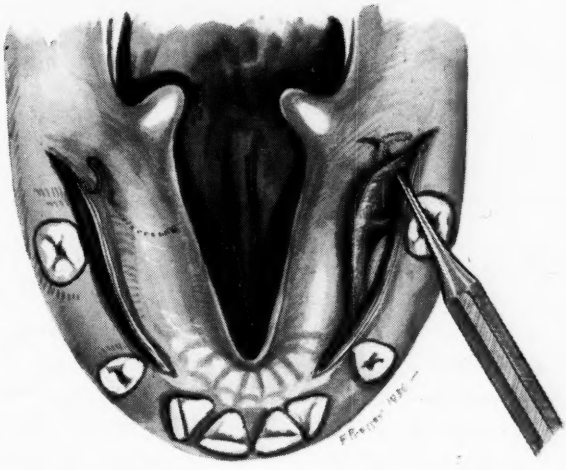


FIG. 84.—The elevator is introduced into the incision and the hamular process broken off.

at the edge of the cleft. The mucous membrane over the tip is either lacerated thereby, or can be gently scraped through, using preferably a sharp-pointed dental scaler. This incision is carried round, dividing the junction between the oral and nasal mucosæ along the whole extent of the hard palate cleft. Two oblique

incisions are now made on either side. Each incision commences at the posterior end of the hard palate and at the border of the cleft, and runs obliquely forwards and outwards (*Fig.* 85). The mucoperiosteum of the hard palate is completely severed and, of course, at this point there is often free bleeding. As a result of this procedure one is left with four flaps, two anterior and two posterior.

The transversely oblique incision is made for a number of reasons. Firstly, Veau pointed out that when the hard palate is left intact, as in the Langenbeck operation (or Axhausen's modification), the mucoperiosteum is, as it were, left in mid-air with a raw upper surface which must inevitably granulate and, of course, give rise to dense scar tissue. Veau then devised his well-known method for the formation of flaps based upon the posterior palatine arteries, in which the upper raw surfaces were permitted to lie snugly against the bone from which they had been detached (*see Fig.* 77). Personally, I had never felt happy about the long

FIG. 85.—The mucoperiosteum of the hard palate is completely severed by an oblique incision.

Veau flaps, which rely on their blood-supply from a source which is liable to suffer a good deal from trauma, or even become kinked over the hard rim of the foramen through which it passes to reach the flaps. This kinking must be exaggerated during the suturing, and it has been my experience that, in the widest types of cleft, one of the principal factors preventing the flaps meeting in the midline is the intact posterior palatine arteries. I am not convinced that pulling these vessels out of their bony canals can preserve a blood-supply adequate to allow one taking any liberties. Consequently, by a gradual process, the oblique incision of Veau was brought farther and farther back, till now it is commonly made from the posterior edge of the bony palate; thus forming a very short posterior flap which allows of deliberate division of the posterior palatine artery wherever necessary, and without any more fear of destroying its blood-supply than would obtain in a similar flap anywhere else in the body.

Starting on the left side, the posterior flap is picked up either with a hook or with fine dissecting forceps, and is raised from its bed. Using once again an elevator, the flap is dissected up until the posterior free edge of the bone is reached. The elevator is then inserted behind the posterior edge until the soft palate is completely freed from the bone, and only remains attached by the mucous membrane on its nasal, or upper surface. The elevator is then introduced on the upper surface of the hard palate, between the bone and its nasal mucosa, and this again is carefully raised along its whole length. After this procedure has been carried out, it will be observed that the principal structure which remains fixing the soft parts of the palate to its bony parts is the posterior palatine artery and its sheath; and, in many cases, it will be noted that, unless the artery be divided, the palate cannot be sutured without tension. To deal with this the artery is

FIG. 86.—When necessary, the posterior palatine artery is seized, cut through, and then twisted.

gently pulled as far as possible out of its canal. A fine artery forceps is applied to the vessel close to the bone, and it is cut through and twisted (*Fig.* 86). This now leaves the whole of the bony attachment of the soft palate exposed to view, and the dissection is continued near the base of the hamular process and the maxillary tuberosity, and along the posterior border of the internal pterygoid plate, until the whole of the palate is quite loose and almost falls back into the naso-pharynx (*Fig.* 87). It is advisable to take care, while carrying out this dissection, that it is not continued too far along the internal pterygoid plate; otherwise there is a risk of damage to the attachment of the Eustachian tube. If the separation is not felt to be free enough, a finger pushed into the lateral incision will often sever the few remaining strands which are anchoring the palate. Finger dissection is not by any means a new idea, and the first surgeon I saw practising it was Professor Grey Turner.

Now, when the wound is opened up for inspection, it will be found that there is a large space on the outer side into which the lateral incision opens. It is bounded on the inner side by the palate, and on the outer side by the tendon of

the internal pterygoid muscle, which is often plainly visible. This space may be freely opened, since it does not communicate with the deep fascial spaces of the

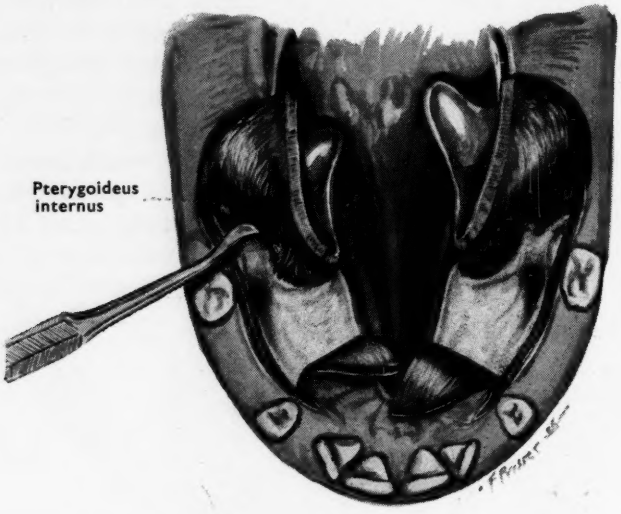


FIG. 87.—The greatest care is taken to get free separation of the soft palate from the bony surface of the hard palate. Note position of the pterygoideus internus muscle, and the fact that the nasal mucosa remains intact.

neck, and consequently any infection arising therein should not track into the mediastinum. The exact anatomical boundaries of this space have been worked

FIG. 88.—The edges of the soft palate cleft are freshened by excision of a strip of mucosa.

out by my colleague, Mr. J. Whillis, and he assures me that any infection would tend to point behind the angle of the jaw.

The operation, as described on the left side, is now carried out on the right; and, when both sides have been completed, it is found that the halves of the palate often lie in contact with the pharyngeal wall, and with one another.

The next part of the operation consists of freshening the edges of the soft palate and the uvula, preparatory to suturing. This is done by excising a strip of mucous membrane by the usual method (*Fig.* 88); but often it is found that a little extra freedom can be gained by making a small snip with the scissors in the soft tissues, at the very front of the inner surface of the soft palate and close to the nasal surface (*Fig.* 89).

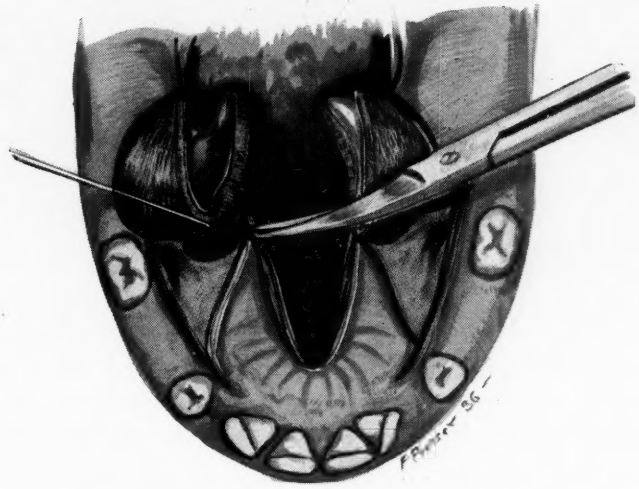


FIG. 89.—A little extra freedom and thickness of palatal tissue will sometimes be obtained by making a small cut with the points of the scissors as indicated.

Stage 3: Completion of the Pharyngoplasty.—This consists in tying the pharyngoplasty sutures which were inserted in *Stage* 1. This process is delayed till this stage of the operation, because it is found that the raw edges of the incision now come together readily and without tension, and at the same time they drag with them the halves of the freed soft palate. Moreover, the soft palate is now held in a position of considerable posterior displacement.

Stage 4: Suture of the Flaps.—The process of repair is now commenced, and begins in front by suturing the mucous membrane from the nasal surfaces of the hard palate (*Fig.* 90). These are joined together in the midline, using fine catgut mounted on a Reverdin needle after the well-known method of Veau. Several of the more anterior of these sutures are tied and left long, being held by small artery forceps. These are used later to anchor the flaps and prevent them from falling into the mouth. The suture of the nasal mucous membrane is carried along over the whole length of the soft palate and uvula. The under surface of the soft palate is sutured with fine catgut, as advocated by Gillies, or with fine silkworm gut inserted in the fashion of the end-on mattress stitch. One or two of the more posterior ones take large bites of tissue and are tied lightly. There is no need for tight suturing, because everything is so loose that suturing can be carried out without tension.

As soon as the soft palate is completely repaired on nasal and oral surfaces, attention is directed to the two anterior flaps, which are raised from the underlying bone and united by two or three end-on mattress stitches. Next, the cut

FIG. 90.—The nasal mucosa is sutured according to the method of Veau. Note that two of the sutures have been left long to anchor the flaps.

edges of the mucoperiosteum of the hard palate (i.e., the edges of the posterior flaps), are united in a similar way (*Fig.* 91); and it is found that, in order to make the anterior and posterior sets of flaps meet at all, the suturing must be continued

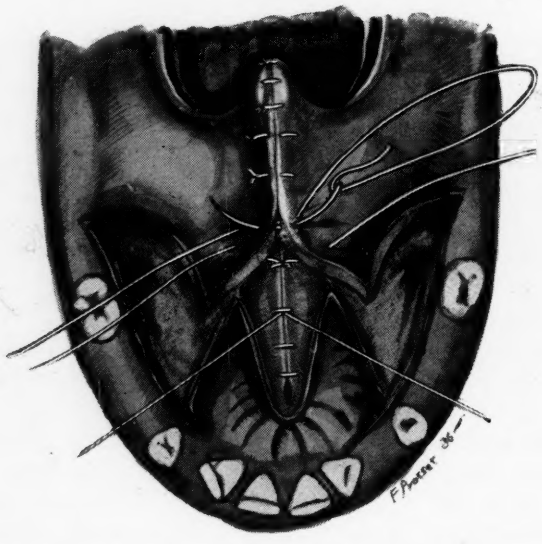


FIG. 91.—Insertion of the sutures into what was formerly the mucoperiosteum of the hard palate.

some distance along the posterior edge of the oblique incision (*Fig.* 92). Thus it is easily seen, as shown in the accompanying diagram (*Fig.* 93), that considerable backward displacement of the soft palate has been effected, and in fact a form of

V Y advancement carried out. In addition to this, there is a small gain in the fact that both anterior and posterior sets of flaps are subjected to internal rotation.

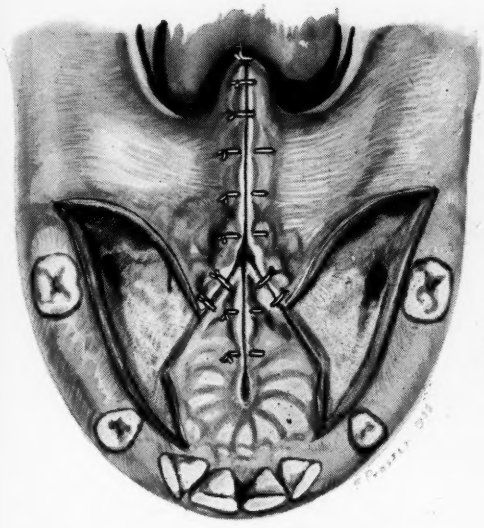


FIG. 92.—Completion of the suture line.

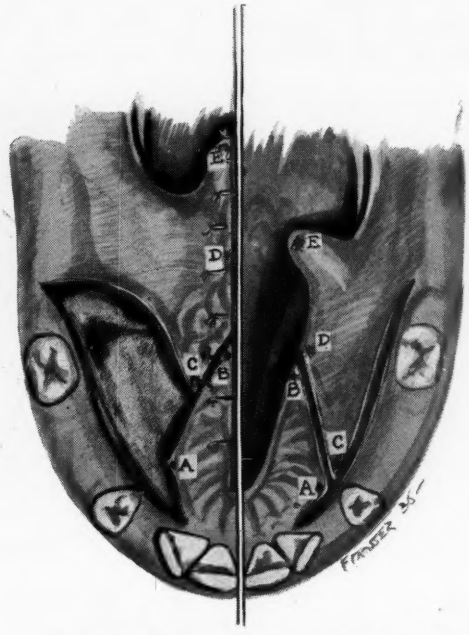


FIG. 93.—Illustrates diagrammatically how, by cutting flaps in the method described, a form of V Y advancement of the velum takes place. The letters indicate corresponding positions before and after operation.

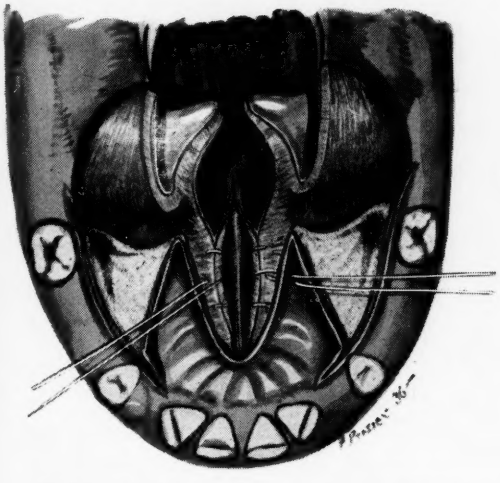


FIG. 94.—The mucosa from the nasal surface of the hard palate is united to the vomerine mucosa. The situation of the stay sutures is shown.

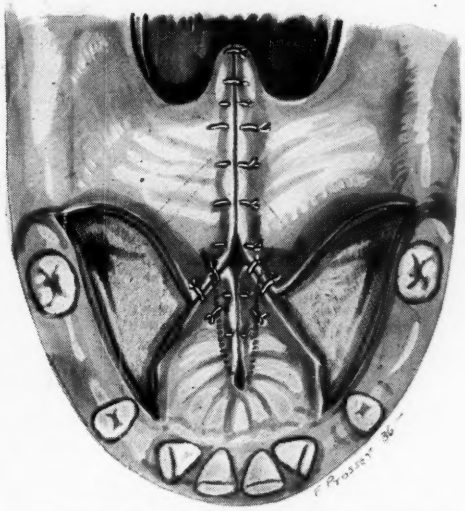


FIG. 95.—Repair completed. The dotted line shows the approximate situation of the united nasal musoca.

When it is found that the two sets of flaps are able to meet, the catgut sutures which were used to unite the nasal mucosa, and which were left long, are mounted

on a needle and passed through both sets of flaps (*Fig.* 94). These act as stay sutures, and prevent the flaps from falling from their bed into the mouth. Two stay sutures only are required as a rule, and it is as well in passing them to arrange, if possible, that the suture line in the palate does not directly overlie that in the nasal mucosa; as by this means there is less liability to the development of holes.

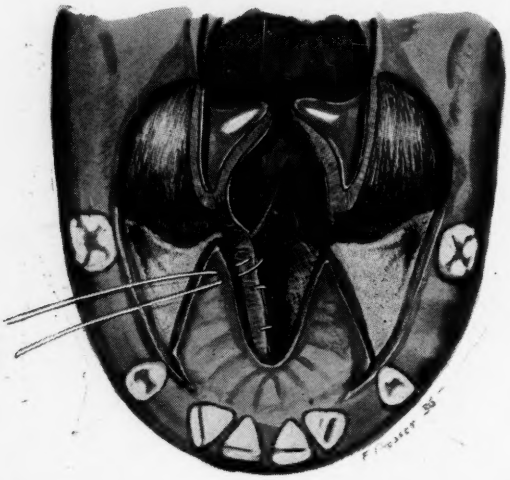


FIG. 96.—The vomer is attached to one side of the hard palate; its mucosa can be stripped as shown and used to form a floor to the nose.

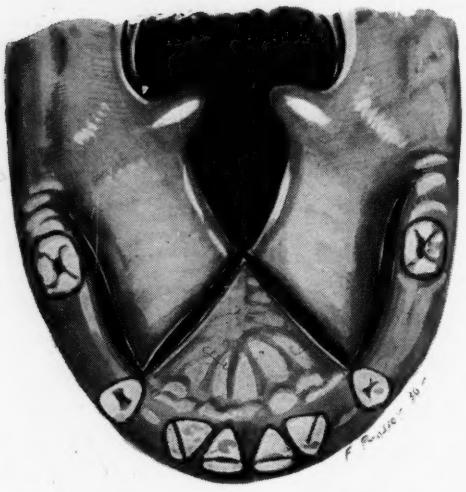


FIG. 97.—Line of incision for a soft palate cleft.

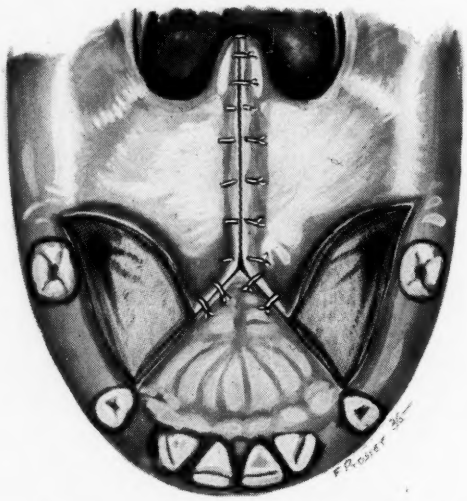


FIG. 98.—Repair completed. Note degree of advancement.

This completes the repair of the palate; but, in concluding the operation, it is sometimes advisable to pack firmly the large dead space at the posterior ends of the lateral incisions with 10 per cent iodoform gauze, as is recommended by Ernst. The gauze, according to Ernst, may be left in situ for as long a period as a fortnight, in which time the palate should be firmly united. The lateral spaces then heal up quickly without giving trouble.

The method as described and illustrated applies to that type of case where the vomer is not a prominent feature. Where the vomer is well developed, much use can be made of its mucosa, as shown in the pictures (*Figs.* 94, 95).

If the vomer is attached to one or other half of the hard palate, as a unilateral cleft, its mucosa is used as in *Fig.* 96.

In clefts involving the soft palate only, the same principles as outlined above should be applied, as shown in *Figs.* 97, 98.

Complete clefts, that is those involving the alveolus and the lip, whether unilateral or bilateral, should have their anterior ends closed at the time of repairing the lip. This method belongs to Veau, and I am indebted to him for permission

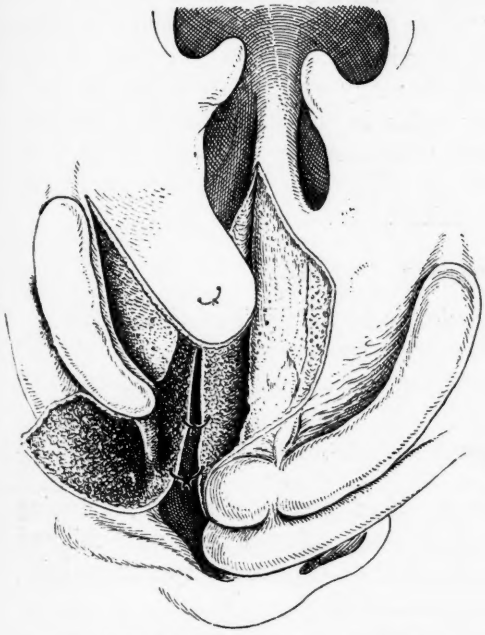


FIG. 99.—Where the cleft is complete, the hard palate should be repaired as shown above at the same time as the lip operation.

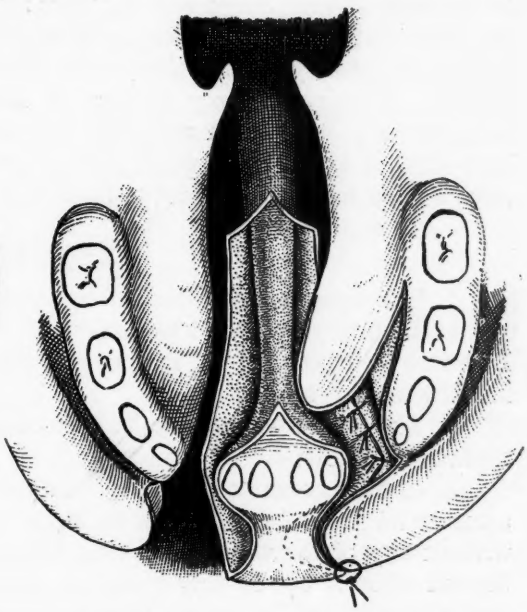


FIG. 100.—The same principle applies in the case of the bilateral cleft.

(*Figs.* 99, 100 *reproduced by kind permission from "Division palatine", by Victor Veau.*)

to publish some of his illustrations (*Figs.* 99, 100), which are self-explanatory. If the Veau technique is followed, the subsequent repair of the palate is greatly facilitated.

AFTER-RESULTS

In the earlier of my cases operated upon by the above-described method it was found that there was a tendency for the anterior and posterior flaps to separate at the four-cornered point where they had been sutured together. In some cases both sets of flaps came completely apart and left a considerable hole. This was always thought to be due to giving way of the mucous membrane of the nasal surface, and was regarded as being a great disaster. Observation of these cases over a period of years has shown that the holes tend to close very rapidly; and, owing to the situation being well in front of the mobile velum, they close without

any apparent forward pull upon it. This part of the suture line, however, still remains a weak point in the operation. Occasionally a hole develops, or one or other posterior flap separates from the anterior flap of the same side. With increasing experience, and more careful suturing, the liability to these occurrences is being steadily reduced, and when it does occur no attempt is now made to effect surgical closure of the gap. In some of my cases which have reached the speaking age, it was felt inadvisable for the child to be attempting speech with an incomplete oro-nasal septum, so a small plate has been made to cover the opening. This plate is always made to cover, and not to project into, the gap; and it is amazing to see these children after the course of a few months, when it will be noted that the hole for which the plate was provided has closed spontaneously. Gillies says in his book *Plastic Surgery of the Face*: "Time is the plastic surgeon's greatest ally, and at the same time his most trenchant critic". Certain it is that this is true in the surgery of the palate, since time heals many wounds that have defeated surgery. In my view, any attempt to close holes in the hard palate is entirely unjustifiable; since those which do not close spontaneously are easily dealt with by a small plate, and as most of these patients are obliged to wear a denture in any case, it is no hardship to them to have it extended to cover a small gap.

CONCLUSIONS

1. The operation described above is applicable to all types of cleft palate.

2. It combines the advantages of the Veau operation with Gillies' and Dorrance's operations, and at the same time ensures the formation of a functional nasopharyngeal valve.

3. The operation can be completed in one stage, and requires no special apparatus or after-treatment.

4. Children operated upon by this method before the age of speech, assuming a successful surgical result, grow up in the large majority of cases as normal children without any of the stigmata of cleft palate; and they require no speech training beyond what is customarily given to any normal child.

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ANÆSTHESIA FOR HARE-LIP AND CLEFT PALATE OPERATIONS ON BABIES

By PHILIP AYRE

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THE anæsthesia employed for hare-lip and cleft palate operations at the Babies' Hospital, Newcastle upon Tyne, may be divided into two phases—the nitrous-oxide–oxygen phase and the oxygen-ether phase. In all cases the babies were intubated by the endotracheal technique of Dr. Magill, wide-bore rubber catheters being inserted through the mouth into the trachea just beyond the laryngeal opening. No especial difficulty was experienced in carrying out this procedure, except that on a few occasions the catheter entered a bronchus; this was manifested clinically by laboured respiration and jerky movements of the diaphragm. On slightly withdrawing the catheter, the breathing became normal.

After prolonged trial, we found that, while nitrous-oxide–oxygen anæsthesia afforded excellent results in adult patients, certain grave disadvantages presented themselves when the same anæsthetic was administered to infants. In the first place, the anoxæmia caused by nitrous oxide—and any proportion of oxygen below 20 per cent represents some degree of sub-oxygenation—appeared to be much more deleterious to babies than to adult patients. In the second place, it was extremely difficult to adjust the amount of re-breathing to the small proportions suitable for a baby. No matter how small the re-breathing bag, there was always too much 'dead space', so that the respiratory exchange rapidly became hampered by the accumulation of excess products of respiration.

As a result of anoxæmia and excessive re-breathing, the condition of many babies showed marked deterioration within a short space of time. Rapid, 'snatching' respirations, accompanied by greyish pallor and sweating, presented anything but a satisfactory picture of anæsthesia; while vascular oozing obscured the area of operation and made the surgeon's task more difficult. In most cases so high a proportion of oxygen had to be administered in order to keep the baby a good colour, that quite large amounts of ether were needed to maintain adequate anæsthesia; so that the description 'nitrous-oxide–oxygen anæsthesia' became farcical.

In an endeavour to remedy the above distressing state of affairs (and spurred on by the caustic criticism of a candid surgeon!), the writer sought to devise a method by which the endotracheal technique could still be utilized without the drawbacks associated with nitrous oxide and excessive re-breathing. The following method is simple in the extreme, and has proved highly satisfactory during the last eighteen months at the Babies' Hospital.

Briefly, the apparatus consists of a T-piece which is connected by a short piece of rubber tubing and a Magill angle-piece to a wide-bore Magill rubber catheter previously inserted into the trachea (*Figs.* 101, 102). Through one limb of the T-piece oxygen and ether vapour is delivered from a Boyle or other continuous-flow apparatus. The other limb remains open to the outside air; for convenience,

a short piece of tubing may be attached and allowed to hang down beneath the operating towels. A strand of fine gauze, fixed with adhesive strapping close to the open end of the latter tubing, will wave to and fro with the patient's respirations, thus serving as a useful indicator to the anæsthetist. *Fig.* 103 shows the special T-piece described above, which may be obtained in two sizes.*

The advantages of this technique are as follows :—

1. The baby inhales fresh air and oxygen under as nearly normal physiological conditions as possible. The system is open to the outside air, without the intervention of a re-breathing bag, expiratory valve, or other obstruction to normal respiration. Sufficient ether vapour is added to the oxygen to maintain adequate anæsthesia, the baby being kept just short of 'gagging'. Deep anæsthesia is neither necessary nor desirable.

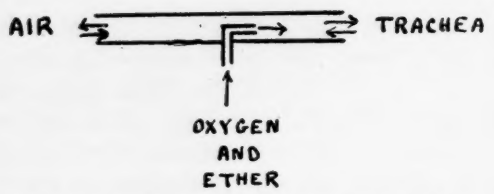

FIG. 101.—Diagrammatic representation of T-piece.

FIG. 103.—The author's T-piece connected up to the endotracheal tube.

FIG. 102.—Photograph taken at conclusion of operation for hare-lip. The endotracheal tube is still in position. The T-piece has been adapted from a Clausen-Evans pharyngeal air-way.

2. The 'dead space' is reduced to negligible proportions, while the continuous flow of oxygen at the rate of from 1½ to 3 litres a minute flushes out the lungs, and effectually prevents undue accumulation of respired products.

The excellent colour and quiet, natural breathing of the babies have convinced us that oxygen and ether vapour, administered by the T-piece method, is the anæsthetic of choice for all hare-lip and cleft palate operations on babies and young children. Not only is the general condition of the patient very satisfactory throughout operations lasting from 30 minutes to 1½ hours, but the post-operative convalescence is remarkably smooth and free from anxiety. Last, but by no means least, comparative peace now reigns in an operating theatre formerly the scene of many sanguinary battles!

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FOREIGN BODIES IN THE URINARY BLADDER WITH A REPORT OF TWO CASES

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THE occurrence of foreign body in the urinary bladder is comparatively common. W. P. Manton[1] collected 455 titles and papers on this subject from 1880 to 1916. Goldman[2] states that from 1919 to 1930 inclusive there were 151 articles published in the literature of the world. From 1931 to 1935 inclusive there have been a further 57 articles published, giving an average of 12 to 13 articles per year. As each article contains the report of at least one case of foreign body in the bladder, and as undoubtedly many cases go unreported, the occurrence of foreign body is therefore far from rare.

MODE OF INTRODUCTION

The method or way of introduction of the foreign body varies, but may be classed under one of the following headings: (1) Through pre-existing channels, e.g., the urethra or a skin fistula; (2) As a result of trauma; (3) Post-operatively; (4) Via the alimentary tract.

1. Through Pre-existing Channels.—Many strange, indeed completely bizarre, foreign bodies have been described, and the majority of these have been introduced along pre-existing channels. The most understandable foreign body is the part or whole of a surgical instrument which inadvertently is left in the bladder. Commonly the ends of self-retaining catheters, especially in the presence of a dirty bladder, become encrusted with phosphates; the rubber disintegrates and the end breaks off. Similarly, in patients on a catheter life, when the rubber becomes perished, the tip is liable to break off and be retained. Hefferman[3] reports this occurrence on two occasions in one patient, the second time the catheter tip being really a urethral foreign body. Pieces of ureteric catheter and filiform bougies are not uncommonly left in the bladder. Dorman[4] reports an interesting case. The patient had attended with a very narrow urethral stricture, and an attempt was made to dilate it, using a filiform guide with a screw-on attachment. When the instrument was removed, the guide was found to be missing. The patient was admitted to hospital, and further dilatation, using the same method, was pursued. The stricture was dilated up to 20 French size. On pulling out the instrument some difficulty was experienced in extracting the guide, and when it did come, the lost filiform was found securely knotted to the end of it—a rather fortunate and unexpectedly easy extraction of a foreign body. Goldman[2] has removed seven pieces of a glass catheter which had been passed for the relief of post-operative retention.

By far the largest number of cases of foreign body in the bladder are those introduced by the patient. There are two main probable reasons: (*a*) Inadvertently in the female; (*b*) As a concomitant to masturbation.

Inadvertent introduction usually follows an attempt to procure abortion. Slippery elm bark is not uncommon (O'Brien[5] and Bevis[6]), and frequently forms the nucleus of a calculus. Whiteside[7] reports the case of a toothbrush handle, and Schwartz[8] removed a crotchet needle from a girl of 14, who was told by certain of her schoolmates that as she was not menstruating she was probably pregnant, and under the circumstances was advised what to do. A thermometer has been lost when attempting to take the temperature in the vagina, and has subsequently been removed from the bladder (Aspinall[9] and Levy[10]). D'Arcy[11] has had a case of a condom forming the nucleus of a vesical calculus.

The majority of the cases, however, in which the foreign body is introduced by the patient are the result of employing the article as an accessory to *masturbation.* Havelock Ellis[12] states: "The use or rather abuse of the ordinary implements of daily life in obtaining auto-erotic gratification among the ordinary population in civilized modern lands has reached an extraordinary degree of extent and variety". Hairpins are quite common. Manton[1] in his analysis of 455 cases found a hairpin mentioned 93 times. Walther[13] reports a case in which he removed twenty penny wire nails from the bladder. A hog's penis has been introduced into the urethra by a woman (quoted by Gill[14]). It was removed by incising the urethra, but the woman subsequently died of septicæmia.

It has been said that candle wax and chewing gum are probably used for corking up the urethra for contraceptive purposes. Quite a number of male patients, however, in whom these substances have been found in the urinary bladder have confessed to having used them during an orgy of masturbation. Harris[15] reports a case of a candle whittled down to the size of a pencil and introduced into the male bladder in this way. He reviews the literature of this particular type of foreign body. Chewing gum seems comparatively common, and numerous cases have been reported, especially in America. Melen, quoted by Harris, reports a crayon pencil. Vermoolin[16] reports the removal of two blades of grass. Probably the most *outré* of all cases reported is that of Gros, quoted by Gill,[14] who found three caudal vertebræ of a squirrel in a man's bladder. The patient subsequently confessed to having used the tail of a squirrel for masturbatory purposes. In this catagory another zoological curiosity is the decapitated snake, 18 inches in length, removed from a male bladder by Geyerman[17].

2. As a Result of Trauma.—Foreign bodies which gain an entry into the bladder in this way are usually removed almost at once, but Stevenson[18] mentions two well-authenticated cases in which a bullet was passed by the urethra—in one case, some five weeks after the wound was inflicted. Sequestra from an osteitis of the pelvic bone, especially of the symphysis pubis, occasionally pass into the bladder, from which they have to be removed (Chauvin[19] and Loeffler[20]).

3. Post-operatively.—Fowler[21] reports an interesting case of an encrusted suture following a gynæcological operation which gave rise to a localized cystitis of such a degree that the condition was treated as a carcinoma for some months. He also notes that there have been reported 23 cases of suture material, and 7 cases of swabs, including one after herniotomy, found in the urinary bladder. Upchurch and Upchurch[22] report a case in which they had removed a piece of

gauze from the bladder, the patient already having had 102 operations under general anæsthesia, mostly for the removal of gauze from the abdomen.

4. Via the Alimentary Tract.—In the presence of an entero-vesical fistula, naturally the contents of the bowel pass in some measure into the bladder, but it is only with those cases where an actual foreign body passes in this way that we are now concerned. Bond[23] reports a case in which tacks, nails, and glass were found in great quantity in the bladder, having produced, and passed through, an entero-vesical fistula. A returned soldier (Penhallow[24]), in August, 1919, while going downstairs, stumbled and swallowed a bullet which he had in his mouth. He watched the stool, but did not see the bullet. Three weeks later he had an attack of diarrhœa with rectal pain lasting for ten days. This cleared up, and he was free from symptoms for three months, at the end of which time he began to have terminal pain and blood on micturition. A salt-encrusted bullet was found adherent to the back wall of the bladder. Presumably the bullet had ulcerated through the rectal wall into the bladder. Ray[25] had a child of ten years with a needle the point of which was penetrating the bladder wall, the other two-thirds lying free but encrusted with phosphates. During his time in hospital the boy swallowed a safety-pin, and presumably he had also swallowed the needle.

SYMPTOMATOLOGY

The symptoms are those of an acute cystitis—frequency of and pain on micturition, often with terminal hæmaturia and strangury.

DIAGNOSIS

In the large majority of cases the patient will not volunteer a history of a foreign body having been introduced, and, even when confronted with the article subsequent to its removal, will deny all knowledge of it. This applies especially to those articles introduced during onanism. The patient knows that the article is there, and that it probably is the cause of the symptoms; yet it seems extraordinary that he will go for months before obtaining medical advice, and that, when he does so, he will give no help in making a diagnosis. If the presence of a foreign body in the bladder is suspected, two methods of investigation are necessary—(*a*) cystoscopy, and (*b*) radiography. Having done these, the foreign body is usually seen, and an indication is obtained as to the correct form of treatment to be adopted. The diagnosis, however, may only finally be made on section of a calculus when the foreign body is found forming the nucleus (Dukes[26]).

TREATMENT

This naturally depends on the shape, on the size, on the consistency, and on the amount of phosphate deposit around the article. The following are the methods which may be employed:—

1. Cystoscopic Extraction.—This may be comparatively easy. Such objects as pieces of catheter or bougie, grass, or pins may be grasped with the rongeur and extracted either along or with the cystoscope. The method is not free from danger, however, and should not be pursued if the foreign body is not mobile, since perforation of the bladder wall readily occurs (Schwartz[8]). Kelly's endoscope may be used in a female in preference to the cystoscope.

2. Manipulation.—This must be rare in its application. It is confined to the female, and was used with success by Aspinall[9] in extracting a thermometer.

3. Solvents.—This is the method of choice in recent cases of candle wax, bees-wax, chewing gum, and similar substances. Caples's[27] experiments are worthy of note. He used a series of test-tubes containing cubes of wax from the same candle as that of which the foreign body was composed. Xylene, kerosene, and gasolin were incubated in respective test-tubes at 37° C., a little urine being added every few minutes. The cubes dissolved in gasolin and xylene in ten hours, in kerosene in eleven hours, and in a solution of 33 per cent gasolin and paraffin oil in twelve hours. He then injected 125 c.c. of the last solution at 110° F. into the bladder. This was retained for 1½ hours. Six subsequent injections were given during the next few days, the wax being precipitated by chilling the return flow. The sixth and seventh specimens were found to be wax free, and on cystoscopy the bladder was clear.

4. Suprapubic Cystotomy.—This is the only method applicable in a large number of cases. When the shape, the size, the consistency, or the position of the foreign body makes other methods dangerous or impossible, then the bladder should be opened and the foreign body removed.

CASE REPORTS

We have two cases to report, both, curiously enough, appearing at St. Peter's Hospital within a week of each other.

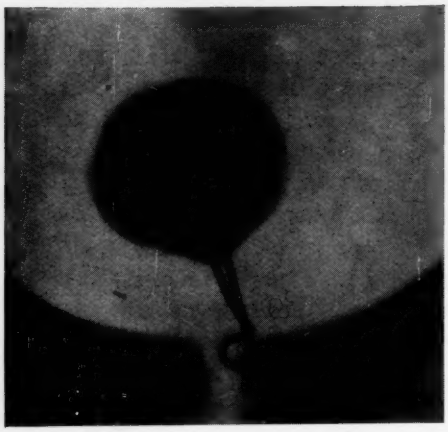

FIG. 104.—*Case* 1. Radiograph showing safety-pin embedded in calculus in bladder.

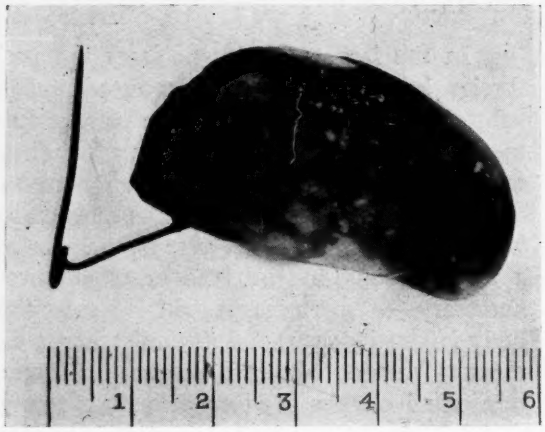

FIG. 105.—*Case* 1. The calculus and safety-pin after removal.

Case 1.—F. L., female, aged 16, domestic servant. She complained of frequency of and inability to control the act of micturition. She gave the history that she had had frequency of micturition at night, three to four times, for some two years, and for the past eight to nine months had had nightly incontinence of urine. During the day she could at times hold urine for some two hours, but usually it dribbled away without her knowledge. She had no scalding or pain on micturition, nor had she ever noticed any blood in the urine.

Twelve months prior to admission to St. Peter's Hospital she had been for six weeks an in-patient of her local hospital, and was told she had inflammation of the kidneys. She had been treated with daily bladder wash-outs. At that time she had not incontinence of urine. She had had no previous illness of any relevance. There was no loss of weight.

PHYSICAL EXAMINATION.—She was well nourished and nothing abnormal was found.

URINE EXAMINATION.—Alkaline, turbid. It contained albumin, pus, and a trace of blood. Triple phosphates were present. There was no sugar or casts. *Sta. albus* and *B. coli* were grown on culture.

CYSTOSCOPY.—A calculus was felt in the bladder with the end of the cystoscope. The bladder was extremely intolerant, and the lotion returned alongside the cystoscope. A large white calculus was seen, but on account of the bladder irritability further examination failed.

X-RAY EXAMINATION.—An oval-shaped calculus was seen lying in the bladder region, and embedded in this was a safety-pin (*Fig.* 104).

OPERATION.—The bladder was opened and the calculus removed. The head and part of one limb of the safety-pin were embedded in the calculus. The pointed limb was quite free (*Fig.* 105). The bladder was temporarily drained through a suprapubic tube.

At the end of twenty-one days the wound was well healed, she was continent, and passing urine normally.

Comment.—On questioning the patient after the presence of the safety-pin was revealed, she denied all knowledge of it, and continued to do so even after she was informed of its removal. Mentally she seemed a little dull, but not to any marked degree. It is probable that this foreign body was used as an accessory to masturbation.

FIG 106.—*Case* 2. Cystoscopic view of leather bootlace in bladder.

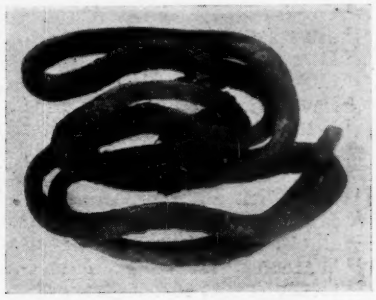

FIG. 107.—*Case* 2. The bootlace after removal.

Case 2.—J. J., male, aged 40, labourer. He complained of hourly frequency of micturition, both diurnal and nocturnal, terminal pain, and occasional slight hæmaturia. He gave the history that five months previous to his admission he had been in a drinking bout with some friends. He could not particularize about it, but apparently he had been kicked on the scrotum. The following morning he noticed a swelling on the scrotum, together with pain at the end of micturition and frequency of the act. About fourteen days after the onset of symptoms he was admitted to the local infirmary, and three weeks later had an operation performed in the right groin. Some weeks later he had a course of bladder lavage. He was in the infirmary for three months without relief of the urinary symptoms.

PHYSICAL EXAMINATION.—His general condition was good. There was a small scar over the right external inguinal ring, otherwise nothing abnormal was found.

URINE EXAMINATION.—Acid, turbid. It contained albumin, pus, and a trace of blood. No sugar, casts, or crystals were seen. Staphylococci and coli bacilli were grown on culture.

The blood-urea estimation was 47 mg. per 100 c.c.

X-RAY EXAMINATION.—A faint shadow of a coiled structure was seen in the bladder region.

CYSTOSCOPY.—A long coiled cord-like object was seen lying in the bladder. It was black in colour, and the surface showed some phosphatic deposit (*Fig.* 106).

OPERATION.—An attempt was made to grasp the object with a lithotrite, but this failed. The bladder was opened and the foreign body removed. It proved to be a leather bootlace (*Fig.* 107). The bladder was temporarily drained through a suprapubic tube.

The wound was healed and he was passing urine normally on the sixteenth day.

Comment.—The patient denied all knowledge of the foreign body. It is possible that, in the drinking bout, the bootlace was inserted by his companions. He was advised to be more careful in future about the company he kept.

SUMMARY

1. The literature on foreign body in the urinary bladder is reviewed.

2. The ætiology, diagnosis, and treatment of the condition is considered.

3. Two cases are reported: (*a*) A safety-pin in a female bladder; (*b*) A leather bootlace in a male bladder.

We have to thank Mr. J. Swift Joly and Mr. R. Ogier Ward for permission to publish these two cases.

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RENAL EXTRAVASATION AND REFLUX

By A. R. C. HIGHAM, London

The aim of this paper is to consider the effects of transference of fluids from the ureteral system to the substance of the kidney, and the various courses open to the intrusive material. It is difficult to frame a wide enough definition in view of the various technical expressions which have been introduced in the literature, but it is hoped that the title of the paper is explanatory of its object.

It is now over eighty years since Gigon[1] observed the first startling fact in what has become a series of apparently conflicting results. He was injecting a solution of potassium iodide into the ureter of a human cadaver, and noticed a profuse flow of the iodide, as tested by starch solution, issue from the renal vein. This occurred at the hydrostatic pressure of 30 cm. of his solution, say just over 20 mm. Hg. This figure is of interest and of great importance, as will be seen later.[17] Gigon stated his facts very clearly, and repeated his experiments on living dogs, also noting the great difficulty of producing the reverse flow (i.e., vein to pelvis), even at much greater pressures. Gigon assumed that the fluid must enter the venous plexuses in the neighbourhood of the renal papillæ, but adduced no proof of this supposition; Zaworykin and Ludwig[2] postulated, but it was not until 1903 that Marcus[6] demonstrated, ruptures at what had been called the fornix calicis by Hyrtl.

Meanwhile Lewin and Goldschmidt[4] had produced fatal emboli by injecting air up the ureters of experimental animals, watching the bubbles pass up the vena cava. This suggests that the path of absorption must be large enough to allow such bubbles to enter the venous system, and would render any explanation of the phenomenon on the lines of diapedesis or osmosis unlikely, although as late as 1926 Hinman and Redewill[21] put forward this explanation.

Tuffier[3] also at this time had made a most important experiment, to which adequate weight has not, as yet, been given in the literature. " J'introduis dans le bassinet d'un chien 2 centigrammes de strychnine au moyen d'une seringue de Pravaz: l'animal n'éprouve aucun accident. Je lie l'uretère: aussitôt les signes d'empoisonnement se manifestent." This means that in the face of obstruction the kidney is able to pass the contents of the pelvis into some part of the absorptive vascular system which has remained at a lower hydrostatic pressure than the secretory pressure (average 80 mm. Hg.). The supposition might have been made after Gigon[1] had noted the pressure at which the veins could be forced.

Whereas up to this time the matter had been of merely academic interest, soon signs of its practical importance were to be found. Rössle[8] and von Hoffmann[15] reported deaths following injection of collargol to obtain pyelograms, the one from sepsis, the other from extravasation of urine following " rupture of the pelvis ". This stimulated investigation, and Blum[10] reported finding globules of collargol in the collecting tubules of a human kidney post mortem, also collections under the capsule and perivascularly in the lymph spaces. He described the X-ray pictures in this case: " Man sieht, das von den Spitzen der Calices Rädiare Streifen bis

an die äussersten Ränder der Rinden substanz verlaufen". This is of interest, as Hinman[24] says that in his experience tubular backflow produces *short* brush-like shadows. Oehlecker,[9] Smith,[11] and Tennant[12] also reported tubular and interstitial backflow in the human kidney. On the other hand, Strassmann,[13] using living rabbits, showed that by using low pressures, collargol did no tubular damage, being found in the veins and lymphatics. Mason[14] and Keyes and Mahan[16] experimentally produced tubular backflow, to Bowman's capsule[14] or to Henle's loop.[16]

At this stage of confusion the matter lay for nine years until Hinman and Lee-Brown[17] conducted their very beautiful experiments on celloidin-corrosion. While investigating the distribution of the vessels of the kidney in sheep and rabbits, they found that after injection of the pelvis with coloured celloidin and digestion of the kidney substance with dilute hydrochloric acid, the celloidin was found in a very large number of cases to have infiltrated the veins, although the reverse injection was very rare. They also showed that there was a ring of veins surrounding the fornices of all multi-papillary kidneys, and that there was very little but epithelium lying between the respective lumina of the vessels in this region. They suggested, as Zaworykin and Ludwig[2] and Marcus[6] had done before them, that there was a direct transference of fluid from pelvis to vein, and they coined the term 'pyelovenous backflow'. It is very largely due to the efforts of these authors that the condition is so well-known now. The pressures used to produce this experimental pyelovenous flow were usually between 40 and 60 mm. Hg, although they found, as Gigon[1] had done, that the flow could be produced at 20 mm. Hg.

Independently Fuchs[18] had been studying the same phenomenon, having learnt from the anatomists at Vienna that demonstration of the renal pelvis by injection was extremely difficult owing to extravasation. In 1925 Vespignani[19] had noticed shadows following pyelograms which he interpreted as tubular backflow, although his description of a "formazione a pennello, a ciuffo o a fiamma di candela" make one wish to see the originals. The description is not so typical as that of Blum.[10]

At this point Bird and Moise[20] conducted some experiments in order to disprove Hinman's theory. They worked with dog's kidneys, and injected suspensions of indian ink and solutions of potassium ferrocyanide and iron-ammonium citrate, at pressures which were gradually increased by increments of 10 mm. Hg to 100 mm. Hg for 2 hours. On section of the kidneys they claimed to have produced injection of the tubules as far as Bowman's capsule, and denied the production of any venous injection. They suggested that any venous injection was accidently produced by rupture of a tubule into one of the arcuate veins.

This led Hinman to reconsider his theory of rupture, and to postulate diapedesis or osmosis in a paper with Redewill,[21] although Lewin and Goldschmidt[4] had shown that large gaseous bubbles could be passed into the venous system. Hinman later withdrew this suggestion, and proved the presence of pelvic ruptures at the fornix.

In 1927 two further facts came to light. Lee-Brown[25] found that "liquids introduced into the renal substance either as a result of pelvic distension or by direct injection into the parenchyma with a hypodermic syringe resulted in a venous injection of the kidney. This was produced without extravasation or tubular injection". And Fuchs,[27] from a careful consideration of his corrosion

specimens, found that in some cases the injection material had run, in the form of a half-cylinder, between the venæ rectæ and the kidney substance for a short distance before entering the vein (vena recta). He concluded that the point of venous penetration lay peripheral to the fornix calicis.

At this time there were two schools, one asserting that pyelovenous backflow never occurred even with pressures of up to 100 mm. Hg,[20] the other that it occurred at pressures as low as 20 mm. Hg, and the same confusion existed as to tubular backflow, Lee-Brown asserting that this did not occur at less than 400 mm. Hg, and Bird and Moise that it did occur at pressures less than 100 mm. Hg.

Sigl[22] suggested that colloidal suspensions entered the smaller tubules owing to reduced surface tension, while solutions tended to rupture the pelvis; Sacco,[30] working under identical conditions with the kidneys of the rabbit and dog, and with careful increments of pressure (20 mm. Hg), produced pyelovenous flow in the rabbit and tubular flow in the dog.

Fuchs[27, 28, 29] was the first to suggest, and Sacco[30] confirmed his findings, that the angle of the fornix calicis was the determining factor, an acute-angled fornix tending to produce a ruptured pelvis (sheep, rabbit), and an obtuse angle a tubular backflow (pig, dog, horse). The kidney of man seems to hold an intermediate position.

CONCLUSIONS

It now remains to correlate these findings and to consider the practical importance of so much careful experimental work.

Both solutions and suspensions can undoubtedly find their way under conditions of low pressure into the human renal venous system from the ureter. No one can doubt that Hinman has conclusively proved that in many cases this is due to a direct rupture of the fornix calicis; equally Fuchs has shown that the fluid may run a short course between vein and parenchyma before rupture into the vein takes place. Also, Lee-Brown has shown that random injection into the kidney parenchyma produces venous injection.

The pressures at which these intravasations take place are low, and backflow can occur at pressures less than the secretory pressure of the kidney.[1, 17] Such flow cannot mechanically persist in face of a higher hydrostatic pressure; therefore tubular backflow cannot occur against secretory pressure.

Tuffier's[3] experiment, where strychnine was not absorbed from the normal renal pelvis but caused toxic symptoms after ligation of the ureter, is probably only explicable by a theory of flow into the low-pressure venous system.

On the other hand, tubular backflow has only been produced at pressures greater than the renal secretion could exert, and this phenomenon, although common as a result of pressure pyelography, is purely artificial. It has been suggested that spasm of the renal pelvis in the nature of retro-peristalsis might cause the tubules to be forced momentarily, but this has never been demonstrated during excretion pyelography where conditions most closely approximate to the normal. Proof of its spontaneous production must be extremely difficult to adduce, and in face of a line of less resistance it must be assumed that the pyelovenous route is more normal for renal resorption, and must be invoked to explain the production of closed hydronephrosis.

The Course taken by Extravasated Fluid.—No doubt most of the extravasated fluid enters the venous system at once, whether the explanations of Hinman or Fuchs be accepted. However, on the latter assumption, the fluid must lie, while it surrounds the venæ rectæ, in a lymphatic space, as shown by Stahr,[5] Kumita,[7] and Blum.[10] This brings forward the possibility of pyelolymphatic backflow.

The subject has been considered by Wood,[26] and by Abeshouse,[34] who collected 11 cases from the literature and added 2 cases of his own. He considered that in all these cases there was a communication between the pelvis and the lymphatic system, and that reflux was a gentle backflow into the great lymphatic trunks. Chyluria was present in 5 of these cases, and is regarded as evidence of communication, whether congenital or pathological, between the renal and colonic lymphatics.

Owing to the extreme difficulty of proving any opening of lymphatic channels into the renal pelvis, I suggest that in all cases where the renal lymphatics are visible on an X-ray film, the contrast medium has been absorbed from the perivascular lymphatic spaces.

RADIOGRAPHIC APPEARANCES

Fine lines running irregularly from the kidney shadow toward the vertebral column were first described by Wood,[26] though the first convincing radiograms are depicted by Abeshouse.[34] Bartrina[32] shows typical fine straying lines, but considers that these represent pyelovenous flow. He does not explain why the medium

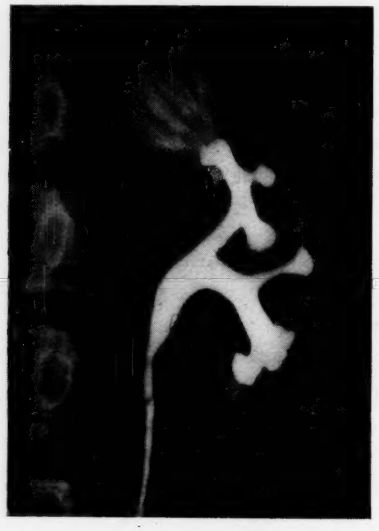

FIG. 108.—Radiograph showing tubular backflow. Note fine striations running from upper, middle, and lower calices to extreme limit of cortex.

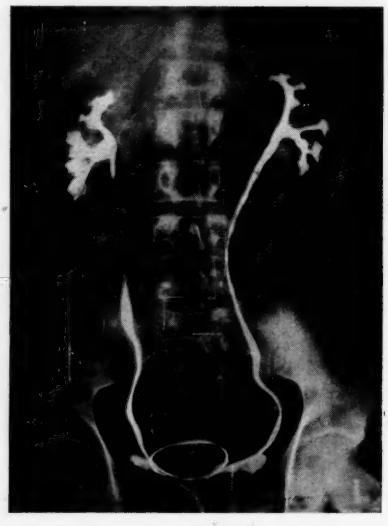

FIG. 109.—Radiograph showing lymphatic, pyelovenous, tubular, and interstitial backflow. Note: (i) Lymphatics outlined on both sides; (ii) Tubular backflow in upper and middle calices on left side; (iii) Pyelovenous backflow on both sides, with arcuate veins filled; (iv) Hilar extravasation on left side. Cf. *Figs.* 110 and 111.

has occupied so small a portion of the renal veins, and dismisses the possibility of lymphatic flow owing to the difficulty of seeing the openings of the lymphatics into the pelvis, "even in chyluria".

A later German paper, by Eichler,[35] also shows typical lymphatic shadows, and he terms them "pyelovenöser Reflux", although the ready solubility of the injection fluid and the rapidity of flow in the renal vein would seem to indicate, if any shadow at all, a mere blur as wide as the renal vein. It must be said that

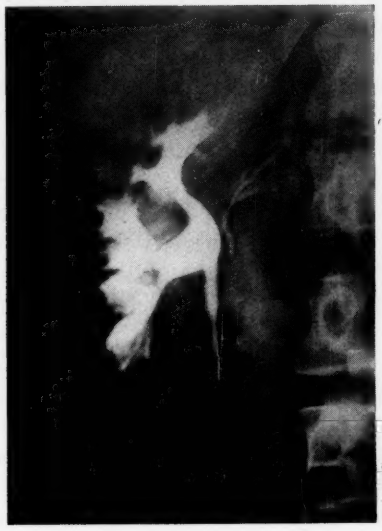

FIG. 110.—Enlarged view of right side of *Fig.* 109. Cf. *Fig.* 112.

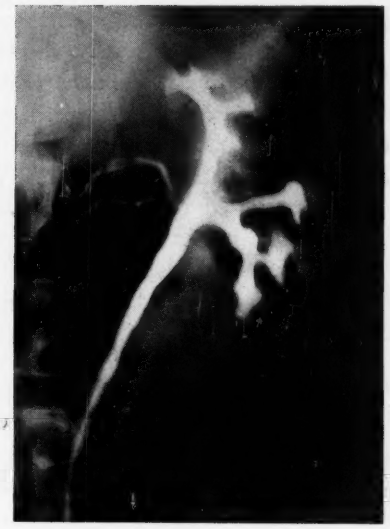

FIG. 111.—Enlarged view of left side of *Fig.* 109. Cf. *Fig.* 113.

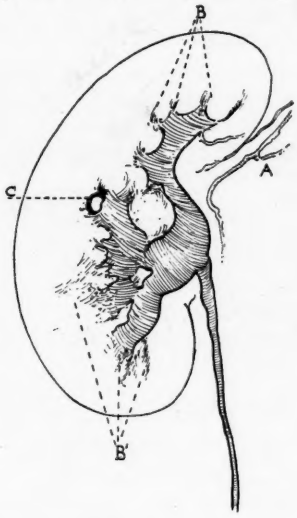

FIG. 112.—Outline drawing of *Fig.* 110. A, Lymphatics; B, Pyelovenous backflow; C, Arcuate veins.

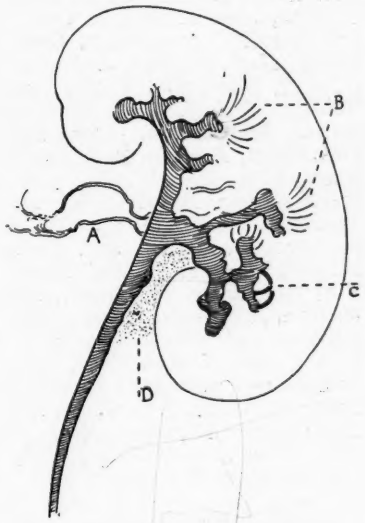

FIG. 113.—Outline drawing of *Fig.* 111. A, Lymphatics; B, Tubular reflux; C, Arcuate veins; D, Hilar extravasation.

a more likely explanation is pyelolymphatic flow. In the author's case, the two sides were exposed, not simultaneously, but with an interval of seven minutes, during which any contrast medium (in this instance uroselectan B) must have flowed out of the vein first injected.

Tubular backflow gives very typical pictures, as first described by Blum,[10] and later by Vespignani,[19] Hinman and Lee-Brown,[17] Fuchs,[18, 27, 28, 29] Perrin and Rolland,[31] Ciocca,[33] and Eichler.[35] Hinman stated that the short brush-like radiations never extend into the cortex, but Blum's original description[10] and the author's *Fig.* 108, as well as Eichler's pictures, do not support this. Hinman also stated that tubular backflow never occurs with pyelovenous, but the author's *Figs.* 109–111, as well as Eichler's *Figs.* 3 and 4, show this quite distinctly.

Note that the fine radial striations run from the apex of a papilla, which usually appears flattened or even inverted.

Pyelovenous backflow shows in the early stages as a horn or a deep band running out from the fornix calicis into the kidney substance. This appearance would also be given by medium lying in the perivascular spaces; but when the arcuate veins are outlined as in *Figs.* 109–111 it must be inferred that the venous lumen has been penetrated.

Occasionally some of the medium runs into the subcapsular space, as shown by Eichler,[35] or into the peripelvic tissues at the hilum (*Figs.* 109, 111).

In conclusion, I should like to express my gratitude to Mr. C. Jennings Marshall and Dr. Shanks for permission to publish the radiograms, to the staff of the library at the Royal Society of Medicine for assistance in finding references, and to Messrs. Ilford for advice and assistance in preparing the photographs.

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TUMOURS OF THE URINARY BLADDER
WITH DESCRIPTION OF A NEW ENDOSCOPIC TECHNIQUE

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THE last twenty-five years have seen a remarkable change in the outlook for those suffering from tumours of the bladder. Prior to 1910 the prognosis even for the so-called simple papilloma was virtually hopeless, and death brought a happy ending to months of agonizing strangury. A fuller realization of the characters of these bladder growths, and improvement in surgical technique, with introduction of ancillary therapeutic agents—notably high-frequency currents and gamma rays—have all played their part in this creditable chapter of surgical history. Though the picture has thus changed materially, and results are being obtained of which we may well be proud, "we are still far from the goal at which we are aiming" (Beer).

I propose in this paper to review briefly the nature of these bladder tumours and their diagnosis, to consider the most widely used methods of treatment, and to submit a new endoscopic technique employing the endothermy cutting current, which I have found of singular service in dealing with a number of such tumours.

PATHOLOGY

A very great variety of tumours occurring in the urinary bladder have been described. The following list (after Hinman) covers the vast majority:—

A. EPITHELIAL (95 per cent).—
1. Adenoma and endometrioma
2. Papilloma
3. Carcinoma
   - *a.* Papillary { Non-infiltrating / Infiltrating
   - *b.* Scirrhous
   - *c.* Medullary } Infiltrating
   - *d.* Squamous }
   - *e.* Adenocarcinoma

B. MESOTHELIAL.—
1. Sarcoma
2. Myxoma
3. Myoma
   - *a.* Fibro-adenoma
   - *b.* Leiomyoma
4. Fibroma
5. Vascular tumours
   - *a.* Angioma
   - *b.* Hæmangioma

C. HETEROTOPIC.—
1. Rhabdomyoma
2. Dermoid cyst and teratoma
3. Chondroma
4. Cholesteatoma

Of these tumours 95 per cent may be grouped under the three headings: (1) Papilloma; (2) Papillary carcinoma; (3) Flat infiltrating carcinoma.

Though this simple classification suffices fairly adequately from the standpoint of clinical diagnosis, it leaves much to be desired on pathological grounds. Many transitional forms of tumour are found, parts of the same growth showing the microscopical characters of a simple papilloma, other portions those of a papillary epithelioma; again, other tumours show for long the microscopic and clinical characters of a simple papilloma, but develop in later years into frank carcinoma.

It is becoming more and more the practice to regard all these epithelial tumours of the bladder as carcinomata, and the aim to classify them on some such basis as that suggested by Broders. This grading depends on a consideration of the proportion of undifferentiated cells in a growth indicating cellular activity, and not on the gross or cystoscopic appearance. If about three-fourths of the tumour is composed of differentiated epithelium and one-fourth of undifferentiated, it is graded I; if the differentiated equals the undifferentiated, it is graded II; if the undifferentiated forms three-fourths of the tumour, it is graded III; and if there is no tendency to differentiation of the cells, it is graded IV. Recognizing that different portions of the same tumour may present very different microscopic appearances, classification on the above basis presupposes that the whole tumour is available for section. This is, of course, not always feasible or desirable, but with recent developments in the taking of portions for biopsy, segments may be obtained from different parts of the growth, and the average grading is fairly representative of the whole tumour.

The routine taking of specimens from all papillary tumours of the bladder has been eschewed by most urologists on the grounds that: (*a*) The procedure is not devoid of the risk of disseminating the growth; and (*b*) Little, if any, additional help is obtained, in that the trained cystoscopic eye can, with a small margin of error, divide these tumours into benign and malignant groups. Certainly the methods formerly in vogue for obtaining such specimens (rongeurs and the like) do not appeal, entailing as they do the withdrawal of viable tumour cells along the urethra. The introduction of newer methods, however, rendering the procedure virtually bloodless and safe, should lead to an adoption of the more precise diagnostic aid afforded by the microscope. When the approximate degree of malignancy of the tumour under consideration is known, the surgeon may the better decide on the mode of attack most likely to succeed, and be in a better position to give a prognosis. Even expert cystoscopists nod, and with the routine use of biopsies, unnecessary heroic surgery should become a thing of the past. The classical case in the literature in which a total cystectomy was carried out on a bladder which contained no neoplasm, needs no comment.

As it is only recently that I have adopted the Broders classification, and most British urologists have been content with the simple division of the tumours into papilloma, papillary carcinoma, and flat infiltrating carcinoma, I shall adhere to this latter classification in this paper.

The typical papilloma shows microscopically an orderly arrangement of epithelial cells, ranging from columnar to transitional, grouped about a central connective-tissue stalk, in which blood- and lymphatic-vessels are visible. The epithelial cells are more or less uniform in size, shape, and staining properties. The deeper cells are rather polyhedral or columnar, the superficial layers tending to become

flattened, and resemble the transitional type seen in the normal bladder mucosa. An inflammatory process may be present, and cause a leucocytic invasion of the central stalk, with some œdema of the superjacent cells. Even apparent glandular or cystic formations may be present, but these should not be mistaken for evidence of malignancy.

The usual criteria of malignancy are: variations in the size and shape of the cells, with nuclei staining more deeply and of freak shapes; atypical mitotic figures; multinucleated cells; and fusion of adjacent papillæ. The loss of orderly arrangement of the cells, with breaking through of the basement membrane, leaves no doubt as to the malignant character of the tumour. Where no evidence of malignancy or malignant metaplasia is evident, the tumour is classified as 'benign'; in the non-infiltrating papillary carcinoma the malignant changes are evident only on the surface of the tumour, the base in close proximity to the bladder wall being uninvolved; in the infiltrating type, the underlying bladder wall is involved in the cancerous process.

SYMPTOMS

The outstanding symptom of tumour of the bladder is a painless hæmaturia, usually intermittent, and in almost 90 per cent of cases this is the initial symptom and may long remain so. Generally speaking, in the absence of other vesical pathology, such as stone, painful urination only develops on the advent of infection, or the development of clots in the bladder owing to excessive hæmorrhage. The common intermittent nature of the hæmaturia, especially in the smaller growths, is remarkable. The blood is usually intimately mixed with the urine, and clots are relatively infrequent. Where the growth is situated in close proximity to the vesical outlet, the blood may only appear mixed with the terminal few cubic centimetres of urine passed at each micturition. In the less solid and more papillary tumours, bleeding is more likely to occur early in the disease; but where the neoplasm is of the solid, carcinomatous type, the bleeding may only manifest itself late.

Tumours close to the bladder neck may give rise to difficulty of micturition, and the symptoms may suggest prostatic obstruction ("corked urethra" of Kidd). The painful micturition associated with infection of the urine is more likely to occur in the case of frankly malignant tumours, though necrosis in a benign growth, as seen in a personal case of a very large fibro-adenoma attached by a relatively small pedicle, may cause intense dysuria. Where tumours are located close to a ureteric meatus, dilatation of the upper urinary tract on the corresponding side may lead to symptoms of hydronephrosis. Metastases, in general, occur late, so symptoms referable to secondary deposits are seldom the initial complaint. In advanced cases of vesical carcinoma the urine may be foul, and the patient present all the signs of urosepsis; or, again, definite malignant cachexia may be present. Death most commonly results from renal failure. *Fig.* 114 shows a specimen of the kidneys and bladder of a patient dying from the effects of untreated multiple tumours in the bladder.

DIAGNOSIS

Cystoscopy.—Though a tentative diagnosis may be made of papillary tumour of the bladder from the clinical history, cystoscopy is the final arbiter. In some

cases pieces of papillary growth may be recovered from the urine, and microscopy be possible. This, however, is exceptional. Very large tumours may be palpable on bimanual examination. The induration of the bladder base effected by infiltrating tumours may be distinguished per rectum or per vaginam.

FIG. 114.—Kidneys and bladder of patient dying from effects of multiple papillary tumours of the bladder; marked dilatation of both ureters and renal pelves, with cortical abscesses of the kidneys.

In the vast majority, the experienced urologist will have little difficulty in visualizing papillary growths, and assessing into which category the tumour falls, with the margin of error diminishing as experience ripens. Even the most expert, however, will find difficulty in estimating the relative malignancy of some of the solid but non-infiltrating tumours. This is the 'doubtful' group of most authors—an inexact and undesirable term. Generally speaking, the longer the fronds the

more likely is the tumour to be of low malignancy; the more solid the growth the more probably is it frankly cancerous. The presence of necrosis, or the adherence of muco-pus or calcareous deposits to the surface, is an ill omen. Œdema about the base of the tumour is also extremely suggestive that an infiltrating carcinomatous process is being surveyed. Multiplicity of tumours is often taken as evidence of innocence, but such a view is untenable. When dealing with certain 'doubtful' tumours, in circles where biopsy taking is not approved, it is customary to apply cystoscopic diathermy, and review again in three to four weeks. A shrinkage in the size of the tumour is taken to signify innocence, or at all events a tumour which will respond satisfactorily to the effects of per-urethral therapy; an absence of alteration in size, with a non-separation of the sloughs consequent on the coagulative process, indicates malignancy, and calls for suprapubic operation.

The cystoscopic appearance of the rarer non-epithelial tumours presents an almost infinite variety. Ulceration may or may not be present. In the benign connective-tissue tumours enormous growths may develop before symptoms are presented; hæmorrhage may occur very late, and then only when an imperfect blood-supply through a small pedicle has proved insufficient to nourish the gross mass, necrosis bringing its train of infection and hæmorrhage. The rare sarcomata developing in older people may seldom be differentiated cystoscopically from a carcinomatous tumour.

Growths caused by invasion of the viscus by spread from without may assume bizarre forms. Exceptionally, evidence of the site from which the carcinomatous process has emanated may be seen in the ulcerated mass.

Occasionally cystoscopy may prove difficult or impossible. Urethral pathology, such as tight stricture or impacted stone, may call for attention before the passage of a cystoscope is feasible, but it is usually intravesical complications which render accurate inspection of the bladder difficult. When much blood-clot is present it is all-important to evacuate this before attempting to evaluate the size and nature of the growth. A case has recently been seen at All Saints' Hospital where cystoscopy elsewhere caused a diagnosis of vesical carcinoma to be made, and a lengthy course of X-ray treatment was advised and carried out. The hæmorrhage continued unabating, and investigation revealed its source to be a hypernephroma, the 'tumour masses' in the bladder being blood-clot. Even in the absence of clots, fresh hæmorrhage may make the cystoscopy troublesome, and unless a continuous irrigating instrument is available, no clear picture can be obtained. With modern equipment, it will rarely, if ever, be necessary to revert to the older practices of inspecting a bladder through liquid paraffin or a laking medium. The instillation of 2 drachms of adrenaline solution, 1–1000, into the bladder will often check troublesome oozing.

Where the clinical history suggests a vesical tumour but cystoscopy reveals a bladder devoid of pathology save for the mouth of a diverticulum, attempts must be made to visualize the interior of the pouch. In some cases it will be possible to introduce a panendoscope or even a cystoscope, but more frequently such a course is not feasible owing to the position of the diverticulum. The flexible lamp devised by the late Mr. Canny Ryall can be of great service in such cases defying direct cystoscopic inspection. By its use the interior of the pouch is illuminated, and inspection carried out by means of a foroblique or right-angled vision telescope.

Fig. 115 shows the cystoscopic appearance of the mouth of a diverticulum, and

Fig. 116 the inspection of a growth within a diverticulum, which was not visible until the flexible lamp had been introduced into the pouch and the cystoscope lamp

FIG. 115.—Cystoscopic appearance of the mouth of a diverticulum.

FIG. 116.—Papillary carcinoma in a diverticulum visualized with a flexible cystoscopic lamp.

turned off. When the tumour mass projects from the mouth of the pouch this refinement in technique is not, of course, required.

FIG. 117.—Tumour projecting from the right ureteric orifice in a case of papillary carcinoma of the renal pelvis.

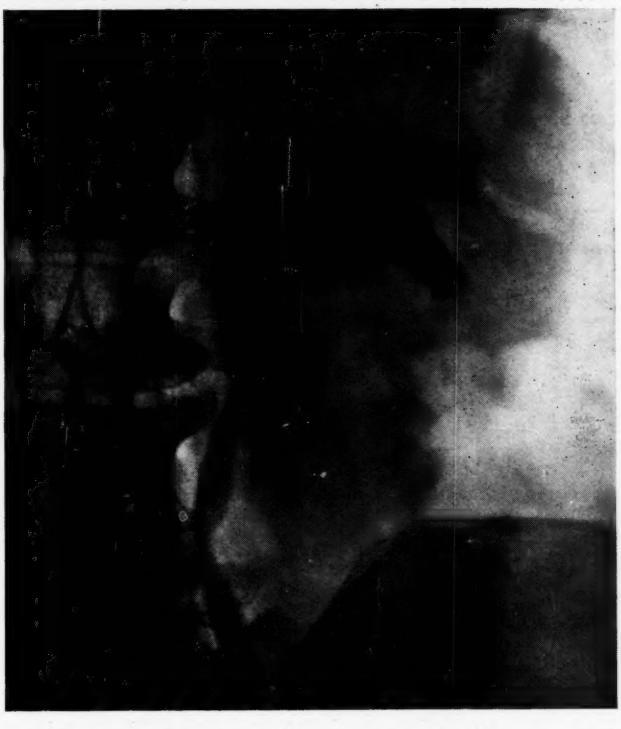

FIG. 118.—Pyelogram in a case of papillary growth of the renal pelvis.

A papillary tumour may present from the ureteric orifice, and in very rare cases this only projects into the bladder, to become visible, at each ejection of urine.

FIG. 119.—Implantation of a tumour in the supramontine urethra.

FIG. 120.—Implantation of a tumour in the inframontine urethra.

In a tumour of this type, or indeed any one situated close to a ureteric orifice, care must be taken to ensure that one is not dealing with implants from a primary

tumour of the renal pelvis. Intravenous urograms may be adequate to rule out a renal origin, but if doubt still exists, an ascending pyelogram should be done after the vesical tumours have been destroyed. *Fig.* 117 shows the cystoscopic appearance of such a tumour projecting from a ureteric orifice. Extensive papillary tumours existed in the renal pelvis, and demanded a complete nephro-ureterectomy, with resection of the bladder wall surrounding the orifice. *Fig.* 118 shows filling defects in a pyelogram caused by a papillary tumour of the renal pelvis.

In every case of vesical papillary tumour, inspection of the posterior urethra should be made lest implants have already occurred in this site. *Figs.* 119, 120 illustrate two cases of implanted tumours in the urethra. In the former the growth was above the verumontanum; in the latter, in the inframontine portion of the

FIG. 121.—Cystogram (retouched) showing filling defects caused by a papillary carcinoma.

canal. Where papillary masses appear to arise around the bladder neck, it is all-important to visualize carefully the prostatic urethra, as the pedicle of the tumour may spring from this site. I have seen two such cases. The first had undergone cystoscopic diathermy to the intravesical tumour masses about the bladder neck on no less than eighteen occasions. A single séance of electro-coagulation to the pedicle in the posterior urethra through a McCarthy panendoscope led to the complete disappearance of the growth. The other case presented a similar appearance, and in it the resection technique later to be described has given a two-year cure to date.

Cystography.—The value of cystography in the investigation of tumours of the bladder appears to have been exaggerated. Admittedly it affords a lasting record of the initial size of the growth, but all too frequently an inconclusive picture is obtained, and clots in the bladder may increase the apparent filling defects. In

some cases the deformity in the contour of the bladder gives a fair indication of the degree of infiltration. Cystography is called for only when, owing to bleeding, a poor cystoscopic view of the tumour is obtained. *Fig.* 121 shows a characteristic filling defect in a cystogram caused by papillary carcinoma. The use of sodium iodide as a contrast medium causes in most cases some very unpleasant hours for the patient. Air cystograms, especially in the presence of a friable, readily bleeding tumour, carry the risk of a fatal air embolus. The less irritating intravenous urographic media still remain costly for extensive routine cystographic use, but diluted with six times their volume of distilled water, adequate pictures are obtained. Where doubt exists as to dilatation of the upper urinary tract, intravenous urography should be practised. In this way adequate descending cystograms are frequently obtained. In some cases where dilatation of the ureters exists, reflux occurs whilst filling the bladder for cystography, and an ascending uretero-pyelogram is obtained.

DIFFERENTIAL DIAGNOSIS

Though few mistakes regarding the presence of a growth should be made by the expert cystoscopist, less experienced investigators may be misled by a few well-recognized conditions simulating neoplasm. In chronic infections of the urinary tract, especially tuberculous, masses of granulation tissue may occasionally simulate papillary tumour. *Fig.* 122 illustrates such a granuloma, confirmed by biopsy. No evidence of tuberculous disease was found, and the tumour was removed completely with endothermic resection.

The bullous œdema overlying the intramural portion or orifice of the ureter when a calculus is lodged in this position, especially where pain is a less prominent feature in the history and hæmaturia present, may also suggest growth. *Fig.* 123 shows a good example of this. Occasionally a stone in the lower ureter leads to a prolapse of œdematous mucous membrane as shown in *Fig.* 124.

Tertiary syphilis may occasionally simulate cystoscopically an ulcerative carcinomatous neoplasm, as seen in *Fig.* 125. This case had been diagnosed as carcinoma, but the elevated edge and sloughy base of the multiple ulcers suggested the possibility of a spirochætal origin. The Wassermann reaction was full positive, and adequate antisyphilitic treatment had a most dramatic effect on the vesical symptoms. The patient ultimately succumbed to a ruptured intrathoracic aneurysm.

Encrusted phosphatic cystitis also may simulate infiltrating carcinoma.

TREATMENT

A great variety of methods of approach and modalities may be employed, personal prejudicies ultimately weighing with each individual surgeon in his selection of the mode of therapy to be employed in each particular case. Before such a decision is made many factors must be taken into consideration :—

1. The nature of the tumour as evidenced by the cystoscopic picture or by microscopy of sections.
2. The size of the tumour.
3. The situation.
4. Associated complications, either within or without the urogenital tract.

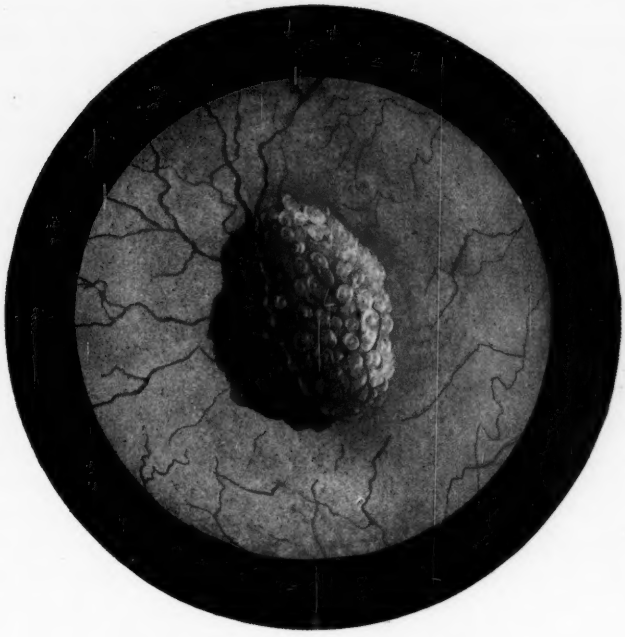

FIG. 122.—Simple granuloma simulating papilloma.

FIG. 123.—Bullous œdema overlying the intramural portion of the ureter in a case of stone.

FIG. 124.—Prolapsed œdematous ureteric mucosa caused by a calculus.

FIG. 125.—Ulcer of the bladder in a case of tertiary syphilis.

Only after due consideration of these factors can the most suitable form of therapy for each case be determined. Briefly the procedures available are :—

1. Deep X-ray or distant radium treatment.
2. Per-urethral approach :—
   - *a.* Diathermic coagulation, using either bipolar or monopolar current.
   - *b.* Endothermic resection.
   - *c.* Introduction of radon seeds.
   - *d.* Aspiration of a bulky, friable tumour (Born).
   - *e.* Chemotherapy. Direct application of trichloracetic acid (Joseph).
   - *f.* A combination of two or more of the above.
3. Suprapubic approach :—
   - *a.* Partial cystectomy or segmental resection.
   - *b.* Total cystectomy with implantation of ureters in bowel or skin.
   - *c.* Diathermic coagulation.
   - *d.* Endothermic resection.
   - *e.* Implantation of radium.
   - *f.* Application of actual cautery.
   - *g.* Low voltage X-ray application direct to the tumour with the Chaoul applicator.
   - *h.* Permanent cystostomy.
   - *i.* A combination of two or more of the above.

Where pain is a marked feature, and uncontrolled by the appropriate use of one of the foregoing methods of treatment, a neurosurgical attack may be indicated :—

1. Presacral neurectomy.
2. Intradural alcohol injection.
3. Lateral chordotomy.

DEEP X-RAY THERAPY

Though in the past the results of deep X-ray therapy have been disappointing, there is reason to believe that, with recent refinements of technique (Coutard) and instrumental improvements, pre- and post-operative courses of treatment are helpful. There is as yet little evidence that the use of teletherapy without the concomitant use of surgery is of service, but the use of X-ray therapy following the ablation of bladder tumours does appear to minimize the probability of recurrence.

PER-URETHRAL COAGULATION

The introduction of per-urethral coagulation by Beer in 1910 was a revolutionary step in the treatment of the so-called benign tumours of the bladder, or papillomata. Surgical approach to these tumours had, ere this, almost inevitably led to a dissemination of the disease, with implantation not only throughout the bladder but in the abdominal wound. This closed method of approach has become firmly established as the treatment *par excellence* for accessible tumours of relatively low malignancy. Aside from minor refinements few developments have taken place in this form of therapy. Its use is now so well established that it is unnecessary to dwell on the procedure.

One or two points, however, appear worthy of mention. The size of the electrode and corresponding current intensity should be chosen according to the size of the growth. The use of a very fine tip in dealing with a large tumour, deemed remediable by this route, calls for much patience on the part of both patient and surgeon; a suitable operating cystoscope, enabling a large electrode to be employed, should be used in dealing with such growths. Kidd's special instrument is preferred by some.

Where extensive diathermic coagulation is indicated, it is best to resort to a low spinal or general anæsthetic. In almost all clinics the bipolar d'Arsonval current is now employed. The most commonly used electrodes are blunt-pointed or spheroidal, but a brush electrode, introduced by the Genito-Urinary Co., of London, has its advocates in that it enables the metallic portion to be freed of debris without removal from the instrument. Without periodic cleaning of the metallic tip, coagulated tissue, with its imperfect conductivity, interferes with adequate destruction of the tumour mass.

The nature of the solution employed in the bladder appears to be of no import, oxycyanide of mercury, 1–10,000, being satisfactory. The advantages claimed for the use of magnesium solutions during treatment have not been substantiated.

Where some doubt exists cystoscopically as to whether a tumour is a papilloma or papillary carcinoma, diathermic coagulation may be employed as a diagnostic test. If after a thorough coagulative séance, cystoscopic inspection four weeks later shows no shrinkage of the tumour, or non-separation of the sloughs, there is strong evidence that the tumour is malignant in character, and will require some other form of treatment. If the growth should thus prove to be malignant it may be argued that valuable time has been lost, but four weeks is a short time in the life of the majority of bladder tumours, and metastasis is late in papillary growths.

In pursuing diathermic coagulation as a form of therapy a number of sittings will usually be required, and it is in general a mistake to carry these out more frequently than once in three weeks. Following the complete destruction of all visible tumours, cystoscopic control every three months for the first year, and, in the absence of recurrence, every six months in the second year, and thereafter once a year, should be insisted upon, the danger of recurrence being pointed out to the patient, and the fallacy of believing that there is nothing wrong because there is no blood apparent in the urine. If the danger of neglecting these periodic inspections be sufficiently emphasized, and cystoscopic examination be carried out with adequate gentleness and employing suitable local anæsthesia, few, if any, patients will neglect to avail themselves of this advice.

PER-URETHRAL ENDOTHERMIC RESECTION

The introduction of the endothermic current, sectioning tissue with a minimum of hæmorrhage in an aqueous medium, has been largely used for the removal of bladder-neck obstructions. Its application to papillary tumours situated in regions of the bladder other than around the neck, has been neglected. A few sporadic reports have appeared in the literature of its employment in dealing with these tumours, but in every case that has come to my notice the Stern-McCarthy resectoscope, or one of its modifications, has been employed. The telescope associated with this type of instrument is primarily designed for close vision, and in my experience is wholly inadequate for dealing with tumours situated elsewhere than

FIG. 126.—Papillary tumour of the bladder the size of a cherry; 4 years' hæmaturia.

FIG. 127.—The loop approaching the tumour prior to endoscopic resection.

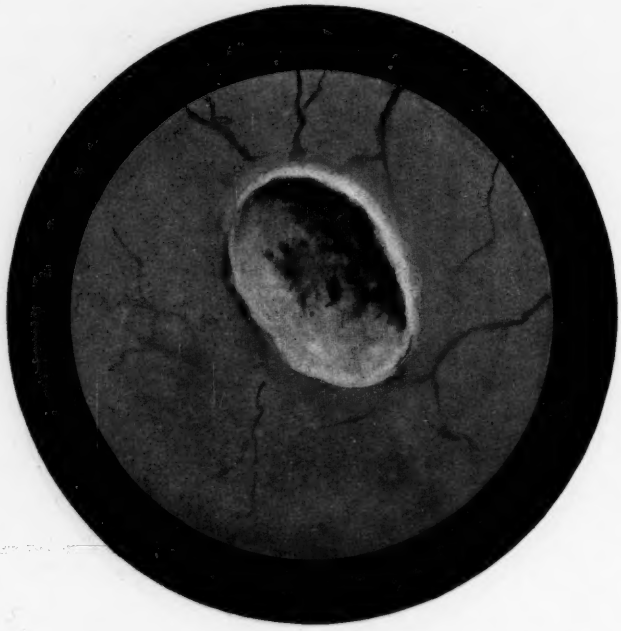

FIG. 128.—Appearance of the base of the tumour after complete ablation.

FIG. 129.—Three weeks later, showing the site from which the tumour had been removed. Four weeks later it was not possible to see cystoscopically the original site of the tumour; patient symptomless and bladder normal.

above the bladder neck. Bearing this in mind, I have constructed an operating cystoscope with adjuncts to be described later in this paper.

Most urologists are agreed that diathermic coagulation of bladder papillomata is the most satisfactory method of treatment in the great majority of accessible papillomata, but a recurrence rate estimated between 30 and 40 per cent cannot be other than a cause of dissatisfaction, and any suggestions leading to improved results should be welcomed. The coagulation technique, effective as it is, suffers from several drawbacks. Firstly, it frequently necessitates multiple sittings, and prolonged cystoscopic séances, especially in the male, are seldom appreciated by the patient. Secondly, the high recurrence rate, recorded from all clinics, is probably not unconnected with the continued passage of viable tumour cells until the growths have been completely destroyed. Any procedure which enables us to destroy papillary tumours completely at one sitting must appeal.

My series of cases, employing this technique, is as yet a small one. The method was first employed some four years ago in dealing with a papillary carcinoma at the bladder neck, and was used during the succeeding three years almost exclusively for this type of case. During the past eighteen months I have been using the cutting current in dealing with ' benign ' papillary tumours in other situations in the bladder with exceedingly gratifying results. *Figs.* 126–129 illustrate one such case.

THE AUTHOR'S METHOD OF ENDOSCOPIC ENDOTHERMIC RESECTION

Armamentarium.—The Stern-McCarthy or Canny Ryall resectoscope may conveniently be employed for resection of papillary tumours situated around the bladder neck, but for reasons given above is not satisfactory for dealing with growths located elsewhere. Flexible loop electrodes passed through an operating cystoscope have been tried, but leave much to be desired owing to difficulty of precise control. In an attempt to provide an equipment which would prove adequate for resecting growths situated in any accessible portion of the bladder, the following armamentarium has been evolved, and has to date proved extremely satisfactory.

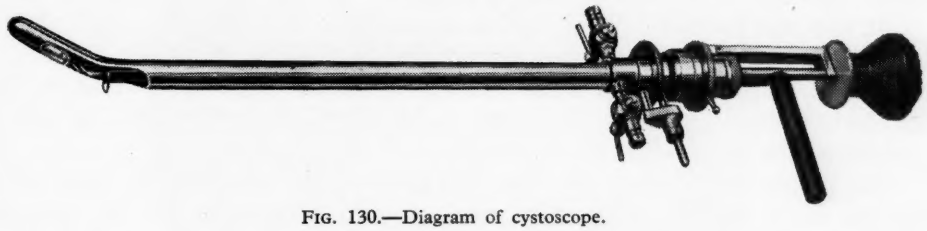

FIG. 130.—Diagram of cystoscope.

1. Constant irrigating operating cystoscope of convex sheath pattern as illustrated (*Fig.* 130). It is made in two sizes. The larger, 28F, enables us to pass a rigid, 6-mm. loop electrode, which will expeditiously resect even a large tumour. The use of this sheath will, in general, demand a caudal block either intra- or extra-dural, or gas-oxygen inhalation anæsthesia. The smaller sheath, 24F, may usually be passed after a local anæsthetization of the urethra with ½ per cent cocaine, or some similar anæsthetizing agent. It will only admit a 3-mm. loop, but this is adequate for resecting the commoner small tumours.

2. Working parts including three channels, one to carry the telescope, one through which the various electrodes may be passed retrograde fashion, and one to connect with the water inflow faucet. A foroblique telescope is satisfactory for most requirements, but when dealing with growths situated in the anterior wall of the bladder, close to the vesical outlet, the retrograde visual system is required.

3. Series of electrodes comprising a number of varying-sized loops, to be selected according to the size of the tumour under revision; a curette to facilitate the removal of blood-clot; a long hypodermic needle with short bevel for adrenaline infiltration; an angled electrode for use in applying coagulation to the pedicle of tumours when this is feasible.

4. Glass cap for converting instrument into direct vision type, which is particularly useful when dealing with grosser degrees of hæmorrhage.

5. Evacuator of Bigelow type for aspiration of blood-clot or bulky, friable tumours.

A diathermy unit which gives adequate cutting and coagulating modalities will, of course, be required, and the two which I have found best to satisfy these conditions are the Genito-Urinary Co.'s apparatus, Model E.D., and that made by the Electro-Medical Supply Co.

Technique of Endothermic Resection.—After appropriate anæsthetization, the selected sheath is passed, and through the special hypodermic needle a few minims of adrenaline 1–1000 are injected into the tumour mass, or into the pedicle when this is accessible. This helps materially to devascularize the tumour. Where a slender accessible pedicle exists it may be preferable to apply coagulation for a few seconds to this by means of the angled electrode, first on one side and then on the other. The loop electrode is substituted for the needle, and the working parts replaced in the sheath. Resection is then carried out as in the corresponding operation for prostatic obstruction. When the tumour has been reduced to a mere projection about 1 mm. above the surrounding bladder mucosa, a coagulating electrode is substituted for the loop, and coagulation applied until an appropriate destruction of the base has been effected. In this way it is possible to remove completely at a single sitting tumours which would require probably three to five séances with the simple coagulation technique.

At the conclusion of the operation the bladder is thoroughly irrigated with silver nitrate solution, 1–5000, to wash out and render innocuous any viable, neoplastic cells which may have been 'spilt'. In cases where large tumours have been dealt with, using the large sheath under anæsthesia, an indwelling catheter is employed for twenty-four hours.

The patient may usually be dismissed from the hospital in forty-eight hours, returning for a routine cystoscopic examination in four weeks. If the operation has been satisfactorily performed, no trace as to the site of the original tumour will be present beyond possibly a slight hyperæmia. (*See Figs.* 126–129.)

Under exceptional circumstances modifications of the above standard technique will be required. When the patient presents himself with a bladder containing much blood-clot, this must first be removed. Under appropriate anæsthesia the large sheath is introduced, and the clots visualized, using the direct vision system. The curette is passed, and the clot masses are broken up and dislodged. The evacuator suffices to empty completely the viscus, when the bleeding points may then be visualized, and the hæmorrhage stopped with the coagulating current.

FIG. 131.—Diathermy electrode approaching a small papillary tumour located in a cellule.

FIG. 132.—Cystic masses springing from the neck of the bladder, seen through the direct vision urethroscope.

When bulky, friable tumour masses are being dealt with, it is my practice to fill the bladder with three ounces of normal saline to which two drachms of

FIGS. 133, 134.—Papillary tumours at the vesical outlet, seen through the direct vision urethroscope.

adrenaline 1–1000 have been added. This is left in for five minutes. The fenestrum of the sheath is then sunk into the tumour mass, and the evacuator attached.

The tumour mass may in this way quickly be reduced very considerably in size, and the resection-coagulation technique then be applied in the standard way described above.

Generally speaking, when very small tumours are being dealt with, the simple coagulation technique is wholly satisfactory, and resection should not be employed. Particular care should also be taken when dealing with tumours situated on the dome or peritonealized surface of the bladder, lest perforation occur. In experienced urological hands this should not happen. It cannot be too strongly emphasized that perfect visualization at all times is essential for endoscopic resection. Where marked trabeculation of the bladder is present, and a small papillary growth is situated in a cellule between two bands of hypertrophic musculature, the coagulation technique is preferable. *Fig.* 131 shows such a small growth.

With careful use of the resection technique it is possible to deal with the majority of solitary papillary tumours of the bladder at a single sitting, and so save the patient a series of cystoscopic diathermic applications. Moreover, it would appear to me more in accord with recognized surgical principles to effect the prompt removal of a potentially malignant tumour than to rely on a method which entails the sloughing away of the growth, and the passage of viable tumour cells in the urine over a prolonged period of time. The relative frequency with which recurrent papillary growths are met at the bladder neck in cases which have had cystoscopic diathermy applied previously to tumours situated higher in the bladder, makes it plain that a number of these so-called recurrences about the outlet are due to the implantation of tumour cells on a surface already prepared for their reception by the inevitable trauma, albeit minimal, associated with the passage of metallic instruments on a number of occasions. Where extensive papillomatosis exists round the bladder neck, diathermic coagulation must be effected through a cysto-urethroscope, but in my view these cases are in the main better dealt with by means of the resection technique. *Fig.* 132 shows cystic tumours of the bladder neck readily removed by diathermic coagulation. *Figs.* 133, 134 illustrate types of papillary tumour of the vesical outlet lending themselves well to endoscopic resection.

Indications and Contra-indications.—There are certain well-recognized exceptions to the application of endoscopic methods in the treatment of papillary tumours. When they are malignant either cystoscopically or on microscopy, and situated in a position lending itself to a relatively safe segmental resection of the tumour and the surrounding bladder wall, open surgery should be advocated. *Fig.* 135 shows an ulcerating infiltrating carcinoma removed by partial cystectomy. Also when growths are situated within or about a diverticulum, open surgery is again the order of the day. Exceedingly extensive tumours, where the resection method outlined above is likely to fail, will need suprapubic section, as will certain tumours associated with prostatic obstruction where the gland is of the large, vascular type, bleeding readily on urethral instrumentation. Again, some tumours situated close to the vesical outlet on the anterior surface of the bladder, lend themselves badly to endoscopic approach, even using retrograde telescopic systems. Where marked infection is present, efforts should be made to clear up the sepsis by means of an indwelling catheter and suitable lavage before attempting surgical intervention either suprapubically or endoscopically. Where profuse bleeding, or other urgent complication, demands prompt surgery, open operation will in general be preferable.

When dealing with frankly malignant tumours, the endoscopic resection technique is useful: (*a*) to secure specimens for biopsy; (*b*) for reduction in size of the tumour prior to the application of electro-coagulation or radon to the base, where the site of the tumour (e.g., base of the bladder) or general condition of the patient precludes a partial or total cystectomy.

Partial cystectomy, and, in rarer cases, total ablation of the viscus, with appropriate deviation of the urine, remain the procedures of choice where the growth is operable, in the complete extirpation sense. All too frequently, however, by the time the patient seeks surgical help, such radical surgery is out of the question. (In MacDonald's series of 120 cases, 85 were deemed inoperable). The surgical problem is how best we may provide comfort to the patient, and at the same time extend his span of years.

FIG. 135.—Ulcerating infiltrating carcinoma of the bladder removed by partial cystectomy.

By utilizing the endoscopic resection technique, I have during the past four years enabled a number of patients, with inoperable vesical carcinoma, to carry on in comparative comfort without having recourse to a suprapubic intervention. Generally speaking, before the introduction of the resection technique, the procedure of choice in dealing with papillary carcinomata, inoperable from the partial cystectomy standpoint, has been suprapubic section with endothermic resection of the tumour mass, followed by deep coagulation of the base. In some cases radon seeds have been introduced, but we have not been satisfied that this helps the final outcome. With the new endoscopic technique, the same type of resection and electro-coagulation may be carried out with a minimal risk, as opposed to a 15 per cent average mortality associated with the suprapubic operation.

TECHNIQUE OF SUPRAPUBIC APPROACH OF VESICAL NEOPLASMS

The inevitable bugbear of the open approach to these papillary tumours is dissemination of the pathological process (*a*) to other parts of the bladder, (*b*) to the wound and abdominal wall. It is a curious but well-established fact that the

implants in the abdominal wall, even following attacks on histologically benign bladder tumours, are malignant. The most meticulous care must be taken to avoid spilling neoplastic cells in or about the wound. With the patient in the Trendelenburg position, a vertical midline approach of generous proportions is employed, after the bladder has been thoroughly irrigated and emptied. The bladder is exposed in the usual manner, and by dividing the urachus and seizing the lower end in tissue forceps, it is so freed that it may be virtually exteriorized. A self-retaining retractor is employed to spread the recti muscles, and large, dry, gauze swabs are packed between the bladder and wound margins, so that no raw surfaces are exposed. The bladder is seized on either side of the proposed line of section with Allis forceps. This site will be decided upon pre-operatively after careful cystoscopic charting of the location of the tumour or tumours. Under no circumstances must a growth be traversed in opening the bladder. If growths are situated anteriorly it will be necessary to open the bladder laterally, or through the posterior surface. After complete isolation of the bladder in the manner described, the organ is steadied with the Allis forceps, and then opened with the cutting diathermy needle. A sucker is gently introduced, and any remaining drops of fluid extracted. The cut edges of the bladder are then protected with small, dry, gauze wipes, and the interior of the organ inspected. By introducing a number of stay sutures about the opening in the bladder, and then fixing them to the studs of a Swift Joly self-retaining retractor, adequate exposure will usually be secured, but may be supplemented by using additional retractors carefully introduced so as to avoid trauma to the papillary tumour. Where dealing with very large tumours it may only be feasible to clear the bladder by digital avulsion of the friable masses. Where the tumour is of more moderate dimensions it is covered with a gauze wrung out of 10 per cent silver nitrate solution, and gently drawn away from the bladder wall; the pedicle thus exposed is divided by means of the endothermy needle. The base is then thoroughly coagulated until all hæmorrhage is stopped, and adequate diathermic penetration has been secured. If multiple tumours are present these are dealt with in rotation until all visible growths have been removed. At the conclusion radon seeds may be implanted. The recently introduced low-voltage Chaoul X-ray unit may well have a place at this stage, careful application to the base for an appropriate time securing a more evenly distributed dosage than any method of implantation of seeds or needles. This method is still on trial. At the conclusion of the operation, before removal of any of the isolating swabs, all intravesical instruments are abandoned, and the bladder is then filled with 50 per cent alcohol, which is allowed to remain *in situ* for five minutes. This is aspirated, the swabs removed, and the wound similarly treated with alcohol, as advocated by Beer, to kill any neoplastic cells inadvertently spilled. With careful adoption of this technique implants should be exceedingly rare. The bladder is sutured round a drainage tube in the usual manner, and the wound closed.

Where the tumour is situated within a diverticulum, the technique is virtually that of a diverticulectomy, but care must be taken in manipulating the diverticulum to avoid spilling tumour cells. The combined extra- and intra-vesical approach is employed, the pouch containing the tumour being resected along with a generous portion of the surrounding bladder wall. In many cases it will be necessary to section the ureter and re-implant into the bladder elsewhere, the simplest possible technique being the best.

PARTIAL CYSTECTOMY

When pre-operative studies have suggested the feasibility of practising a partial cystectomy, the suprapubic approach is similar to that above described. Before the bladder is opened it must be thoroughly freed, laterally and posteriorly, down as far as the crossing of the ureters by the vasa deferentia. In some cases where the peritoneum is firmly adherent to the bladder, it will be necessary to open the peritoneal cavity, delineate and resect the adherent portion, and again close the cavity. In this way the bladder is fully extraperitonealized. After packing off, as described above, the bladder is opened, the growths destroyed with diathermic coagulation, and the base of the tumour, along with 1·5 cm. of surrounding bladder wall, excised with the cutting current. In many cases the ureteric ostium must be sacrificed, and reimplantation of the ureter effected. The bladder is closed about a drainage tube, and dam drainage provided extravesically.

TOTAL CYSTECTOMY

Complete removal of the bladder is indicated in a limited number of cases. The high mortality associated with the implantation of the ureters into the bowel in malignant cases has led to a reversion towards subcutaneous neostomy. Fourteen to twenty-one days later the cystectomy is proceeded with, either by the more commonly adopted suprapubic approach, or by the combined perineo-abdominal method devised by Hinman. Where the neoplastic process has involved the prostate, total or partial ablation of the gland will be required.

RADIUM AND BLADDER TUMOURS

Most British urological surgeons have largely dispensed with the use of radium in treating tumours of the bladder. As J. F. McCarthy has put it tritely, " the army of radium enthusiasts of a few years ago has dwindled to a corporal's guard." From time to time enthusiastic reports emanate from radium workers, but it is almost universally held that radium's greatest successes are with the papillary growths—either papilloma or low-grade papillary epitheliomata without infiltration. As these tumours respond equally well, and with less unpleasant sequelæ, to other forms of therapy outlined above, no case has been made for radium. In America the claims of Barringer, and on the Continent those of Darget, amongst others, have received much critical attention. The present position may be summed up briefly by remarking that radium, either the element or its emanation, is not required in treating papillary growths; the results, both immediate and remote, are superior with partial cystectomy, electro-coagulation, or endothermic resection. In the inoperable group of infiltrating carcinomata, cure is not obtained with radium. The technique advocated by Stanford Cade, however, gives gratifying results in a number of such radio-sensitive tumours. A skilfully applied barrage of needles, with screening of 0·8 to 1·0 mm. platinum, introduced suprapubically and left in situ for eight to ten days, does lead to a marked retrogression of such tumours, and may keep the bladder free from growth for two years and over, distant metastases often causing death before a local recurrence develops. With inadequate screening, burns may occur, and the plight of the patient be made infinitely more intolerable owing to severe cystalgia and urinary frequency. In many cases falling into the surgically inoperable group, we do better for our patient by carrying out a permanent

cystostomy. Radium has been advocated for use in checking hæmorrhage from vesical tumours. It is undoubtedly serviceable in this connection, but electro-coagulation usually suffices, and, in addition to being more precise, is without the unpleasant sequelæ so commonly met with after radium applications.

RESULTS OF TREATMENT

The records of 172 cases of vesical tumour have been studied. In addition to 76 personal cases, I have reviewed many records of the late Mr. Canny Ryall, and the case sheets at All Saints' Hospital. Many cases have proved untraceable, and it has not appeared desirable to offer any comprehensive statistical review. Certain clear-cut facts, however, stand out. The prognosis in *solitary* papilloma of the bladder is relatively good. With adequate cystoscopic diathermic treatment, some 65 per cent are free from recurrence at the end of 3 years. If new growths appear after this period they may be regarded not as recurrences but as fresh neoplasms. Two cases have been met which showed a normal bladder more than 10 years after diathermic destruction of a solitary papilloma, yet later developed another tumour—one in the 11th, the other in the 13th year.

RESULTS OF SUPRAPUBIC OPERATION ON PAPILLOMA OF THE BLADDER (*see p.* 170)

PATIENT	AGE	NATURE OF TUMOUR	YEARS SINCE OPERATION	COMMENTS
R. J. P.	64	Solitary tumour	5¼	Bladder remains tumour free
W. S. B.	76	Multiple tumours	4½	Bladder remains tumour free
Mrs. G.	64	Huge solitary tumour ..	4½	Bladder remains tumour free
H. B. S.	66	Multiple small tumours, associated with large stone	3	Multiple recurrences; under control with cystoscopic diathermy
F. S.	66	Solitary cherry-sized tumour of trigone; cystoscopically 'doubtful'	3	Prostatectomy carried out at same operation; 3-year cure
A. E. B.	37	One large tumour; several satellites	1¾	Bladder clear 3 months later; untraced since
W. P.	68	Large recurrent tumour; suprapubic removal 18 years previously	1½	Bladder clear 6 months later; now untraceable
G. B.	73	Huge tumour springing from anterior wall	1½	Partial cystectomy; no recurrence
V. H. B.	62	One large tumour; several satellites in anterior wall	1½	Cystoscopic diathermy elsewhere 3 years before; bladder free since suprapubic operation
J. L.	56	Multiple tumours; many larger than cherry	1	Suprapubic extirpation of solitary tumour elsewhere; recurrence in 9 months; cystoscopic diathermy failed to control. Suprapubic diathermy; bladder now clear for 1 year

The prognosis, *per contra*, in *multiple* papillomata is singularly bad. I have been able to trace only 4 cases whose bladders, following the diathermic destruction of multiple tumours, remained growth-free for 3 years and upwards. One such case required 11 treatments over a period of 9 months for multiple tumours, and has remained cured for 12 years. Though cure is rarely obtained in multiple tumours, they may usually be kept under control with cystoscopic diathermy. One case reviewed has required 65 treatments in 11 years.

The results following open operation for papillomata have in the main been disappointing. Certainly the results in the earlier series were deplorable. With the more careful modern technique the results are very much better. The table on p. 169 gives a series of 10 personal cases of histologically benign papillary tumours operated upon suprapubically owing to size or inaccessibility. During the past year the development of the endoscopic endothermic technique has, with one exception, enabled me to dispense with operation in vesical papilloma. It is yet too early to assess the *ultimate* results of this per-urethral procedure. The *immediate* results have been singularly gratifying.

CONCLUSIONS

1. All papillary tumours of the bladder must be regarded as potentially malignant.

2. Endothermy loop resection affords a safe method of procuring biopsy specimens, and attempts should be made to classify tumours histologically on the Broders basis.

3. A new technique of endoscopic endothermic resection for papillary vesical tumours is presented which may successfully be employed in dealing with most papillomata and many non-infiltrating papillary carcinomata.

4. In infiltrating tumours partial cystectomy should be employed when the location of the growth and general condition of the patient warrant it. In rare cases total cystectomy is indicated. In many cases where radical surgery is not justifiable, the endoscopic resection technique may be employed as a palliative measure.

5. Radium (interstitial needling) is indicated in some non-resectable infiltrating tumours.

I am conscious of my indebtedness to my former chief and mentor, the late Mr. Canny Ryall, that able pioneer in operative cystoscopic work. I have been privileged to draw on his case reports, and, through the courtesy of Mr. H. Kimpton, to utilize several blocks from his *Operative Cystoscopy*. I am also grateful to my friend, Dr. James Miller, for the excellent radiographs, and to Mr. Thornton Shiells for his customary beautiful illustrations.

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ANEURYSM OF THE INNOMINATE ARTERY TREATED BY SURGERY

REPORT OF 3 CASES AND RECORDS OF 22 CASES COLLECTED FROM THE LITERATURE

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THE object of the present communication is to report three cases of aneurysm of the innominate trunk, all treated by surgical methods. In one case the innominate, common carotid, and subclavian trunks were tied simultaneously close up to the aneurysmal sac. This is the first clear record of such an operation being carried out with success. In the second case the three trunks were ligatured and the sac excised. Extirpation of an aneurysm of the innominate trunk has been reported on only one occasion previously. In the third case, in which a fatal termination eventually ensued, the aneurysm had been treated by lesser measures than ligation of the three trunks in the first instance, and it is of particular interest as illustrating the probability of recurrence of pulsation in the aneurysm under these circumstances.

Aneurysm of the innominate artery is not common, comprising, as it does, only about 3 per cent of the total cases. It is, however, a site of peculiar interest to the surgeon, especially when the dilatation affects the termination of the vessel. Under such circumstances it presents a problem more difficult than does ordinary peripheral aneurysm, and is certainly without the hopelessness of aneurysm of the aorta. The possibility of the sac being adherent to the manubrium sterni and other structures, the risk of attempting its exposure, the problem of cerebral and brachial complications following ligature, all call for careful consideration, and contribute to making each individual case a fascinating study.

That the treatment of innominate aneurysm is within the province of surgery is shown by the successful results gained in seven of the last ten cases reported. The striking fact is that the terrain now apparently so secure was won by the surgeon only after continued effort in the face of the most disheartening experiences throughout the nineteenth century and in the early days of the present one. A table is given below summarizing the records of aneurysms of the innominate trunk in which surgical treatment has been adopted. Although the innominate artery has been ligatured on over seventy occasions, it is evident that in the great majority of cases the operation was done for conditions other than aneurysm of that vessel itself. Failure to appreciate this distinction has resulted in great confusion in the literature, both in regard to the frequency of innominate aneurysm and also the efficacy of the various forms of treatment. Indeed, in a recent publication it is assumed that all ligations of the innominate trunk were performed for the treatment of innominate aneurysms, and the mortality of the condition was estimated on this basis. Though the number of cases is small, the table is helpful in indicating the comparative benefits conferred by the different surgical procedures.

TABLE OF REPORTED CASES OF INNOMINATE ANEURYSM TREATED SURGICALLY

(Arteriovenous aneurysms and combined aortic and innominate aneurysms not included)

No.	Operator	Date Reported	Sex and Age	Vessels Ligated	Result
1	Wardrop ..	1828	F.	Subclavian, 3rd part	Greatly relieved, but aneurysm persisted and patient died 2 years later
2	Cooper	1859	M.	Innominate	Death from uræmia
3	Gray	1896	F. 39	Innominate, then 19 days later carotid	Died 42nd day, hæmorrhage and sepsis
4	Gay	1897	F. 39	Innominate, later common carotid	Death from secondary hæmorrhage
5	Schumpert ..	1898	F. 42	Innominate	Death from cerebral complications 9th day
6	De Laup ..	1900	M. 58	Innominate first, common carotid and vertebral 20th day	Died from hæmorrhage 21st day
7	Ballance	1902	M. 35	Innominate	Died from thrombosis of middle cerebral artery
8	Halsted	1907	M. 51	Innominate, partial occlusion of common carotid	Recovery and cure of aneurysm
9	Ballance	1909	M. 35	Innominate	Died 30 hours after operation
10	Da Costa ..	1910	M. 45	Common carotid and subclavian	Well for 18 months after operation, when developed a second carotid aneurysm and died 4 months later
11	Da Costa ..	1910	F. 63	Common carotid and subclavian	Alive and well 5 years after operation, after which could not be traced
12	Baldwin	1910	F. 52	Common carotid and subclavian	Lived 18 years after operation
13	Sargent	1911	F. 67	Innominate and common carotid	Slight recurrent pulsation, which later disappeared
14	Jmai	1913	M. 46	Triple ligature and excision	Alive and well 4½ years afterwards
15	Reid	1918	M.	Attempted ligature of innominate	Death from traction on the aorta before ligature could be placed
16	Ballance	1918	F. 60	Innominate	Lived three years, to die of uræmia
17	Flint	1927	M. 37	Subclavian and innominate, ? carotid	Good recovery

[*Continued on next page*

TABLE OF REPORTED CASES OF INNOMINATE ANEURYSM TREATED SURGICALLY—*continued*

No.	Operator	Date Reported	Sex and Age	Vesssel Ligated	Result
18	McCarthy ..	1929	M. 54	Distal arteriovenous anastomosis	Relief of symptoms, but aneurysm not cured
19	Cabot	1929	M.	Common carotid (1st stage operation)	Death from pneumonia
20	Schwyzer ..	1932	M. 31	Common carotid and subclavian	Alive and well 14 years later
21	Souttar	1934	F. 62	Innominate and subclavian	Alive and well 1 year later
22	Ballance	1934	M. 55	Innominate first, then common carotid and axillary	Great relief, patient lived 8 years during which time slight pulsation only was present in the tumour; died following sudden increase in size after exertion
23	Turner	1936	M. 67	1927, common carotid, attempted ligature of innominate 1932, ligature of subclavian 1934, further operation	Died from hæmorrhage a few hours after last operation
24	E. Rock Carling	1936	F. 49	1934, innominate, common carotid, and subclavian	Good recovery, alive 2 years afterwards
25	A. Tudor Edwards and E. Rock Carling	1936	F. 64	1934, innominate 1936, excision	Good recovery, alive and well 1 year later

HISTORICAL

It has been well said that " no concept can be understood except in the light of its history ". The truth of this is nowhere better illustrated than in the present-day treatment of aneurysm.

Galen recognized the dangerous nature of these pulsating tumours, and as early as the second century A.D. Antyllos incised and emptied the aneurysmal sac enclosed between ligatures. Vesalius, over four centuries ago, gave a sufficiently detailed clinical description of aneurysms to indicate clearly his appreciation of the fatal risks associated with them. It was not, however, until the seventeenth century that Harvey's teaching clarified the problem of the circulation and established on a sound footing the dynamics of aneurysm. Then, with the Hunters, William and John, it was realized that the inexorable tendency of these pulsating swellings was to increase steadily in size, resulting in fatal rupture, pressure effects, or gangrene. Later, with Bernouilli, an exact physical explanation was given of these well-proven clinical observations.

In view of such definite and well-recognized indications, it may at first appear surprising that a search of the literature on the subject of aneurysm of the innominate artery reveals records of only 22 cases treated surgically. On the other hand, the chances of wound infection and secondary hæmorrhage were so overwhelmingly great in pre-Listerian days, that operations for ligature of the innominate trunk proved fatal in nineteen of the twenty recorded cases; hence surgery was only justifiable in most advanced aneurysms, where technical difficulties helped further to discourage even the heroic surgeons of those days.

The innominate artery was first ligatured in 1818 by Valentine Mott, but the patient succumbed on the twenty-sixth day from sepsis and hæmorrhage. The operation was done for an aneurysm of the subclavian artery, and not until 1859 was an innominate aneurysm attacked in the same way, by Cooper, again with a fatal result. In 1864 Smyth, of New Orleans, first ligatured the innominate artery without causing the patient's death, and it was the late Sir Percy Sargent who published the first case of aneurysm of the innominate artery at its bifurcation successfully treated in this way. The following extract from Smyth's account of his case of subclavian aneurysm is of interest in giving us an insight into the surgery of the times, and in showing that the successful result was due no less to the patient's extraordinary vitality than to the skill of the operator.

> May 15, 1864: Operation for ligature of innominate and common carotid arteries. Ligature came away from the carotid May 28 and from innominate on June 2; hæmorrhages on May 29, 30, and 31; lint packing, wound filled with small shot on June 1. Further hæmorrhages, and on July 5 terrific hæmorrhage which ceased spontaneously. July 9, ligature of vertebral. All shot removed following day, complete recovery.

In spite of such isolated successes, the early efforts to ligate the innominate artery were so disastrous as almost to parallel ligation of the aorta itself, where, according to Osler, twelve ligations have all proved fatal.

Although in no way curative, there seemed abundant justification for Valsalva's treatment by rest, low diet, and bleeding, or for Tufnell's modified conservative régime; obviously, the average duration of survival would be much longer, and in any case the patients were usually past middle age and suffering from a constitutional disease as a basis.

Wiring and galvanism then made their entry as methods of therapy in intrathoracic aneurysms. First attempted by C. H. Moore in 1864, wiring was later further advocated and modified by Colt and Corradi. It was hoped that with their use the risks of surgical trauma, hæmorrhage, and sepsis would be avoided and yet some actual cure of the aneurysm promoted by causing clotting in the sac. The difficulty of access, the uncertainty of accurate introduction of the wire, the risk of dislodging clots, and the weak nature of the thrombus resulting, make such "coagulation therapy" of no avail, or even dangerous. Reid reported forty cases of aneurysm, one affecting the innominate artery, treated by wiring, without a single cure, relief resulting in only five cases. Wiring and electrical methods have made an ignominious exit. Moreover, compression methods, whether digital, elastic, or instrumental, exceptionally curative in other sites, obviously had, at the most, only an auxiliary value in the treatment of innominate aneurysm (cf. Matas, p. 184).

With Lister, however, and the advent of aseptic surgical technique, the former bugbears of operation, sepsis and hæmorrhage, were minimized, and after 1880

dramatic improvement in the survival rate resulted. Moreover, there was now every justification for, and stimulus to, an early attack on the aneurysm, because if the sac were not large, technical difficulties were greatly reduced, and the risks of shock and primary hæmorrhage were avoided. Hence surgery became a first resort in treatment and not a last one. With such early diagnosis and operative treatment the mortality rate fell further, and we read of Da Costa, in 1910, operating on two cases of innominate aneurysm, the one patient living five years after operation, after which she could no longer be traced, the other living one and a half years, to die from the rupture of a different aneurysm.

The time-honoured procedure is the application of a ligature on the innominate trunk proximal to the aneurysm. This operation was evidently aimed at arresting increase in size of the aneurysm by preventing the oncoming stream of arterial blood from impingeing at pressure on the sac wall, and, except for Wardrop's case, was practised exclusively in all the earlier cases treated surgically. It was used by Ballance in his unique series of four personal cases. But the method proved far from ideal, because it was followed by such a heavy toll of deaths from cerebral and brachial complications, these occurring in nearly 40 per cent of the cases reported.

In 1885 distal ligature of the subclavian and common carotid arteries simultaneously was first introduced by Packard as a lesser measure in large adherent aneurysms, especially if involving the innominate at its origin from the aorta. It is not difficult to imagine the trepidation with which this technique was first used, since it was probably imagined that, to the usual death-roll from cerebral complications there would be added the fatalities due to rupture, when the innominate artery and aneurysm were converted into a cul-de-sac of the aorta, with the sudden resulting rise in pressure of the contained blood.

In practice, however, it has proved very effective. Da Costa's cases were treated in this way; Schwyzer reported his patient to be alive and well fourteen years after the operation, and Baldwin's patient, too, enjoyed a long survival. Moreover, Imbert and Pons, in a complete review of the subject, place the operative mortality due to hæmorrhage and cerebral complications combined at no higher than 15 per cent. Yet in a review of the literature one of the most striking features is the tardy recognition by surgeons of the supreme importance in treatment of applying ligatures distal to the aneurysmal sac.

The next advance logically consisted in the introduction of a triple ligature operation, whereat the innominate trunk was tied as well as its distal branches. By this means cure of the aneurysm would be ensured, and the anxiety attendant on such a case as Sargent's would be avoided. The records of *Case* 1 are therefore of particular interest, not only in affording the first report of an operation in which all three vessels were tied at a single séance, but also, by recording its successful issue, in emphasizing the desirability of this technique.

In the third of the cases reported in this paper it is again seen that unless the subclavian is ligatured in addition to the innominate and carotid arteries, recurrence of pulsation and progress in the size of the aneurysm are prone to occur. Moreover, once the innominate and common carotid arteries have been tied, no further interference with circulation in the upper limb can possibly result from the application of a ligature to the first part of the subclavian artery close up to the sac.

Thompson states that " simultaneous ligature of the three trunks seems to have been very disastrous ", but in an admirable survey of the 52 cases of ligature of the innominate artery collected and published by him in 1915, no instance of such an operation or result is given.

The ideal treatment is ligation of the three great trunks followed by extirpation of the sac, because not only is permanent cure thereby obtained, but also the tumour and all relievable pressure effects are removed. The operation has been successfully undertaken twice; Jmai, a Japanese, published in 1913 a report of excision of an aneurysm of the innominate the size of a small hen's egg, and *Case* 2 in the present series was similarly treated, though a previous proximal ligation had resulted in great reduction in the size of the aneurysmal sac.

A moment's consideration of the anatomy and pathology of innominate aneurysms will make it clear that aneurysmorrhaphy will have little or no place in their treatment. Matas published in 1913 a series of 225 aneurysms treated by aneurysmorrhaphy, but not one affected the innominate artery. Flint's case, however, was treated successfully by a modified endo-aneurysmorrhaphy, but he gives meagre details of the technique. McCarthy, in an excellent article, described 8 cases of aneurysms affecting the aorta and innominate artery treated by distal anastomosis of the right internal jugular vein and common carotid artery, an operation first devised by Babcock; but the technique is difficult, the operation would seem to be subject to many objections on theoretical grounds, and there is no subsequent record of its use.

CASE REPORTS

Case 1.—L. R., aged 49, female. Aneurysm of innominate artery treated by simultaneous ligature of the innominate, common carotid, and subclavian arteries. Recovery and survival after two years.

HISTORY.—Admitted Nov. 21, 1934, complaining of a " thumping on the right side of the neck " present for three years. There had been an ache in the throat and hoarseness for one year; now she felt something in the throat preventing her from swallowing. Recently the patient had slept badly, but there was no shortness of breath; there were no other symptoms. She was married and had three children, all healthy, and had had one miscarriage. She was a woman of peculiar mentality, if not actually suffering from early dementia.

ON EXAMINATION.—The general condition, colour, and nutrition of the patient were good. The voice was apparently normal. On the right side at the root of the neck there was a visible pulsating tumour which lay behind the lower end of the sternomastoid, extending into the suprasternal fossa medially, and into the thoracic inlet below. The pulsation was expansile, and synchronous with the heart-beat. There was a systolic thrill and murmur over the lump and the upper part of the manubrium, but there was no increased dullness to percussion over the right apex. The pulses at the wrists were synchronous and equal, and the blood-pressure 160/110 in both arms. The cardio-respiratory and other systems showed no abnormality to physical examination; the Wassermann reaction was positive.

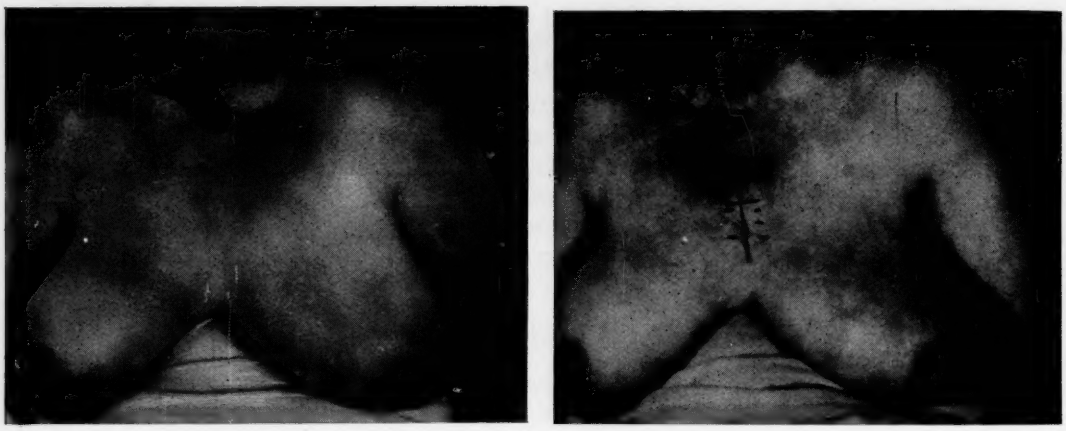
OPERATION.—On Dec. 12, 1934, the aneurysm was explored by Mr. E. Rock Carling and found to involve the innominate artery near its bifurcation and to be very adherent. The innominate, common carotid, and subclavian arteries were all doubly tied with plaited silk ligatures. It was deemed wisest not to attempt excision.

Convalescence was complicated by the development of a slight cough only, the circulation remaining normal in the head and neck and right upper limb, though the radial pulse was no longer palpable. The patient was discharged on the seventeenth day after operation and remained well until three months ago, when signs of dementia paralytica made their appearance, and these have since necessitated her transference to an institution.

Case 2 (*Fig.* 135).—A. C., aged 64, female, single. Aneurysm of innominate artery, treated by proximal ligature June 11, 1935 (Mr. Tudor Edwards). Operation followed by temporary hemiparesis and persistence of local symptoms. Aneurysm re-explored and excised May 16, 1936 (Mr. Rock Carling). Recovery.

HISTORY.—Two years prior to admission in June, 1935, she noticed pain referred to the upper part of the sternum. This was stabbing in character at first, and aggravated by exercise, but for six months had become progressively more severe and accompanied by a throbbing in the right side of the chest and neck. There was some dyspnœa on exertion, but no cough, hoarseness, or dysphagia. A stroke was stated to have been the cause of death of both her mother, at the age of 71, and father, when aged 51.

When examined in June, 1935, there was a swelling with an expansile pulsation extending up into the neck behind the right sternoclavicular joint. The pulsation followed the line of the carotid sheath as high as the level of the cricoid cartilage. The impulse was very forcible, there was a loud systolic bruit, and the whole area was tender on pressure. There was dullness to percussion in the first and second spaces for one inch to the right of the



a *b*

FIG. 136.—*Case* 2. Photograph of the patient (*a*) before, and (*b*) after operation. The area in which an expansile pulsation was seen has been marked with the skin pencil, and is seen to be situated in the suprasternal notch and above the inner end of the right clavicle. The scar after operation indicates the wide exposure necessary for the trans-sternal operation undertaken in *Cases* 1 and 2. (Cf. *Fig.* 142.)

lateral border of the sternum. Over this area, too, was heard a systolic bruit, but there was no impurity of the second aortic sound. Examination of the heart and other systems revealed no abnormality. The Wassermann reaction was negative.

On June 11, 1935, the swelling was explored by Mr. Tudor Edwards. It was found to be a saccular aneurysm of the innominate artery, and was treated by placing two stout silk ligatures on the innominate trunk proximal to the aneurysmal sac. Immediate post-operative convalescence was uncomplicated, but nine weeks after the operation the patient was seized with sudden blindness and loss of power in the right arm and leg. Vision recovered three weeks later, but power and movement returned only gradually to the limbs.

In April, 1936, she was readmitted complaining of pain located, as before, to the root of the neck on the right side and behind the manubrium, but now aching in character and continuous, necessitating the administration of regular sedatives at night. The patient was still conscious of a throbbing in the chest and neck.

ON EXAMINATION.—Her general appearance, colour, and nutrition were very satisfactory. There was some very slight residual hypoæsthesia and weakness on the right side, but all joint movements were free and the reflexes were normal. Local examination revealed a condition similar to that before the first operation, except that there was now a well-marked thrill palpable over the aneurysm and the systolic bruit was very loud.

The radial pulse, which had been impalpable while the patient was in hospital following the first operation, had now returned; the blood-pressure was 125/90 (right arm) and 150/90 (left arm).

In view of the distress occasioned by the persistence of her local symptoms, it was decided to re-explore the aneurysm, and, if possible, to excise it.

OPERATION.—This was performed on May 14, 1936, by Mr. E. Rock Carling, under general anæsthesia. Scar tissue resulting from the previous operation added considerably to the technical difficulties, but the sac, which was found to be much reduced in size, was eventually defined and excised after double silk ligatures had been tied on the common carotid, subclavian, and innominate arteries in turn.

Convalescence was uneventful; the blood-pressure and radial pulse remained as before the operation, the patient being discharged on the seventeenth day. A recent inquiry elicited the fact that she has remained well since. Physical examination of the neck and the central nervous system are both completely negative.

Case 3.—T. G., aged 67, male. Aneurysm of innominate artery at its bifurcation. Ligature of right common carotid and innominate arteries followed by recurrence of pulsation in the sac. Five years later ligature of subclavian and vertebral arteries again failed to relieve condition. Excision attempted, but severe venous hæmorrhage proved fatal.

HISTORY.—When first admitted, in May, 1927, the patient stated that he had noticed a swelling at the root of the neck on the right side after lifting a heavy weight one year previously. It was entirely painless and there was no cough or dysphagia, but the swelling was increasing steadily in size.

PREVIOUS HISTORY.—At the age of 20 he had contracted venereal disease, for which he had received treatment. He had married twice, his first wife having three children, all of whom died within the first few months of life; the second marriage was sterile.

On examination he was a strong, ruddy-complexioned man. The pupils were equal but fixed. The knee- and ankle-jerks were absent on both sides. The mental condition was good.

At the root of the neck on the right side there was a pulsating tumour extending down behind the manubrium sterni into the thoracic inlet. Examination of the heart revealed a muffled systolic murmur at the apex. The pulses were synchronous in both radial arteries. The Wassermann reaction was strongly positive.

On June 7, 1927, the swelling was explored by Mr. William Turner and found to be an aneurysm of the innominate artery at its bifurcation. The common carotid artery was tied twice about half an inch above the sac.

On June 28, 1927, as pulsation was still present to a marked degree, the aneurysm was again exposed and an attempt made to ligate the innominate trunk. The sternum was not split, and difficulty was encountered in securing the ligatures, though the radial pulse could no longer be felt on the right side when the patient left the operating theatre.

The pulse was again felt at the wrist on the day following the operation, but as the swelling, though pulsatile, was diminished in size, the patient was discharged.

The following year he had his prostate removed by a suprapubic operation, and the notes at the time state that "there is a pulsatile swelling at the root of the neck on the right side".

In December, 1932, he again reported, stating that the swelling in the neck was increasing in size and had become painful. Clinical examination disclosed the presence of a pulsatile tumour as before, and radiological examination of the thorax showed the heart to be somewhat enlarged and general dilatation of the aorta to be present.

On Jan. 4, 1933, Mr. Turner ligated the right vertebral and subclavian arteries and divided the right common carotid between ligatures. In spite of this the swelling still pulsated slightly, but was smaller when the patient was discharged on Jan. 20.

In August, 1934, the patient was readmitted. The swelling was gradually increasing in size and its throbbing had become more pronounced. Lately, too, the patient had often been awakened at night by a feeling of suffocation.

ON EXAMINATION.—A large pulsating tumour the size of an orange was noted at the root of the neck on the right side. It had a marked expansile pulsation synchronous with the heart-beat. The left radial pulse was more forcible than the right.

It was considered that the previous attempt at ligation of the innominate artery had been ineffective in obliterating its lumen, and it was determined to excise the sac *in toto* if possible.

OPERATION.—The medial half of the clavicle was resected. Scar tissue from the previous operation made the dissection very difficult, and before the sac could be properly isolated severe venous hæmorrhage necessitated plugging of the wound. Four days later this plugging

was removed, but serious hæmorrhage immediately recurred and plugging was again resorted to; the patient, however, died shortly after the operation.

POST-MORTEM.—It was found that the aneurysmal sac was "the size of a tangerine orange" and that, though it contained much laminated clot, its lumen was still patent. The innominate artery had evidently not been occluded at the third operation. Marked syphilitic and atheromatous changes were present in the aorta.

DISCUSSION OF THE CASES

Ætiology.—Two of the patients were suffering from syphilis, the other was not. This corresponds roughly with the usual findings in aneurysms affecting the great arterial trunks as opposed to those in the aorta itself. In elderly subjects such aneurysms are found apart altogether from a syphilitic taint. It is interesting to note that in the case in which the Wassermann reaction was negative both parents had died from vascular causes. Two of the three subjects were women, and there was no history of trauma in either case, but the man dated the appearance of his swelling from a severe muscular exertion.

FIG. 137.—This drawing illustrates the classical saccular type of aneurysm of the innominate artery involving the terminal part of the trunk and the bifurcation. Surgical treatment has given good results in this variety. (*R.C.S. Museum*, No. 5438.1.) (× ½.)

FIG. 138.—In this specimen a fusiform aneurysm of the ascending aorta is seen to involve the origin and proximal part of the trunk of the innominate artery. No surgical treatment has proved of any value in this type. (*R.C.S. Museum*, No. 5355.1.) (× ½.)

Pathology.—In all three cases the aneurysm was a saccular one and affected the distal half of the innominate trunk. As was pointed out originally by Ballance, such is the usual type and site of innominate aneurysms, so that if adequate exposure is obtained proximal ligation can almost invariably be performed. Aneurysms of the innominate artery fall naturally into three pathological groups: The first and commonest is the saccular aneurysm affecting the distal part of the vessel and involving its bifurcation (*Fig.* 137). Next in order of frequency is the aneurysm which involves the innominate artery at its origin from the aorta (*Fig.* 138); it is really a combined aortic and innominate arterial dilatation, and would be more properly regarded as an aortic aneurysm. The third, a rare type, is where the dilatation affects the trunk of the innominate artery; in these cases the sac at first is fusiform, and shows a general tendency to progress proximally or distally, merging into the other types.

At operation the tendency of these arterial swellings to contract adhesions to surrounding structures was well shown, and this precluded removal in *Cases* 1 and 3. One of the structures most likely to be injured because of involvement in surrounding fibrous tissue is the recurrent laryngeal nerve, and this required careful separation in *Case* 2.

FIG. 139.—*Case* 2. Specimen after removal. The cut section of the innominate trunk, with a constriction marking the site of the first ligature operation, can be seen on the right of the photograph. The aneurysm is seen to be involving the termination of the vessel. Much patchy atheroma and internal degeneration are evident. (× 2.)

In *Case* 3 the sac was adherent to the posterior aspect of the manubrium sterni, and had spread to involve almost the whole length of the innominate artery. The veins normally in relation to the innominate trunk are separable at a first operation without very great difficulty provided that the aneurysm be not too extensive; but in this case the progress in size of the aneurysm and the increase in the density of its adhesions, augmented as they were by the previous operation, rendered the task of its excision one of insuperable difficulty.

The specimen excised from *Case* 2 was bisected longitudinally and mounted so as to show the innominate trunk on the right (*Fig.* 139). Close examination of

the photograph reproduced shows that the arterial walls are thickened and that there is patchy atheroma of the intima. At the site of the first ligation there is an incomplete occlusion of the lumen by a fibrous diaphragm, which in the fresh specimen freely admitted a blunt probe at its centre. It is remarkable that in spite of the application of two silk ligatures, the wall of the vessel at this site shows no change in the structure of its middle coat, although it has been constricted (cf. Thompson's case on p. 184). The diaphragm formed was evidently responsible for the widespread thrill felt, before the second operation, over the manubrium and the root of the neck.

The extraordinary degree of contraction that can occur in this type is well illustrated in the specimen, there being only a small saccular dilatation to mark the site of what was formerly a moderately large aneurysm. Ballance has published a case which similarly shows the way in which even an advanced aneurysm can contract down to quite small dimensions after treatment by ligature proximally.

Clinical Aspects.—The cases are of interest clinically for their long histories, although in no instance was the aneurysm a particularly big one when the patient first reported. The average duration of symptoms before the patient sought treatment was two years.

The feeling of a lump in the root of the neck and a distressing throbbing sensation or actual pain caused the patient to report, and this is what one would expect with a pulsating tumour situated actually at the thoracic inlet.

In all three cases the pulsation was easily visible in the neck, and it is a noteworthy feature that aneurysms of the innominate artery are often misdiagnosed as affecting the carotid, such confusion arising from an insufficient appreciation of the clinical effect of the obliquity of the thoracic inlet, and the fact that the aneurysm usually affects the distal part of the vessel.

The principal aims of clinical examination are to form an estimate of the patient's general condition and the advisability of surgical treatment, and to determine the precise situation and size of the aneurysm, the extent of its adhesions, and the efficiency of the circulation in the territory supplied by its distal branches.

Of special importance in the general examination is a close scrutiny of the central nervous and cardiovascular systems, especially in cases with a syphilitic ætiology. It is probable that cerebral complications are more common following ligature operations in syphilitic patients, particularly if early signs of dementia are already present. Symptoms and signs suggestive of aortic or valvular disease should be carefully noted, since it is of the utmost importance both from the point of view of prognosis and treatment to distinguish between aneurysm confined to the innominate trunk and combined aneurysm involving both the innominate and aorta. Clinical examinations must be aided by careful radiological examinations if the precise situation and size of the sac are to be determined, having due regard to the advisability of screening and oblique views.

More valuable than pressure symptoms in estimating the extent of the adhesions of the sac will be signs of sympathetic or recurrent laryngeal nerve involvement, as indicated on the one hand by ocular changes and sweating and vasomotor disturbances in the corresponding upper limb and the head and neck of that side, and, on the other, by hoarseness and loss of mobility of the

homolateral vocal cord or its fixation in adduction. Clinical and radiological examination will also determine the presence of tracheal displacement and elevation of the diaphragm, suggesting implication of the phrenic nerve.

Venous engorgement of one or both sides of the body above the thoracic inlet due to obstruction of the great veins, severe pain or paralysis from plexus pressure, or tenderness, hyperæmia, and bony absorption of the manubrium, are all late signs, but do not necessarily contra-indicate active treatment.

In investigating the adequacy of the circulation beyond the aneurysm the patency of the contralateral common carotid must first be determined. In all three cases pulsation was easily felt in that vessel, but the importance of establishing its patency before embarking on surgical treatment was well illustrated in the case published by Cooley and MacNamara, in which in addition to an innominate aneurysm there was also occlusion of the left common carotid artery. In all the patients the pulse was easily felt in the peripheral branches, but though this probably indicates an adequate circulation, great diminution or even absence of pulsation in the vessels beyond the sac does not necessarily contra-indicate operation on the grounds of vascular impoverishment. It is well to remember in this connection that the pulse is primarily a vibration propagated rapidly throughout the arterial tree, having really no physical relationship to blood-flow. Hence the pulse may be damped out by a large adherent sac with inelastic walls although the blood-flow in the part beyond may be quite sufficient for the needs, especially if there is any concomitant venous obstruction aiding in the opening up of collateral anastomotic channels. An interesting point, too, in illustrating the great degree to which such vascular channels dilate and even ' arterialize ' is the reappearance of the radial pulse after ligature of the innominate trunk, as noted in *Case* 2. This emphasizes again the indeterminate relationship between the palpability of the pulse and the volume flow along the main trunk.

TREATMENT

If the general condition is satisfactory, and the cardiovascular system, apart from the innominate artery, shows no gross affection, then surgical treatment is strongly indicated, because thereby relief or cure can be given to the patient in an otherwise steadily progressive and fatal condition.

Criteria of inoperability include such considerations as the following :—

1. Other severe syphilitic manifestations, especially cerebral.
2. Involvement of the aorta, as in a large combined aneurysm.
3. The presence of severe aortitis, with aortic valvular regurgitation.
4. The presence of impaired renal efficiency, always to be suspected in these cases.

Moreover, early diagnosis and operation will give the best results, because there will be less difficulty in technique and treatment can be more thorough at this stage.

Simple proximal ligature was used in all the early cases recorded, but of recent years one or other of the terminal branches has nearly always been tied in addition, as shown in the table. Cerebral vascular complications were common following the application of a proximal ligature alone. Some increase in the amount of clot in the aneurysmal sac rapidly occurred, and, with the early development of recurrent

anastomotic channels, and refilling of the sac with blood, fragments of such unorganized clot were swept off into the distal branches to lodge at the first site of bifurcation.

Alternatively, fragments of pre-existing clot were liberated into these distal branches in the process of mobilization of the parent trunk preparatory to the passage of the ligature. Thus, Ballance quotes a case treated by proximal ligature alone, death occurring thirty hours after operation, the patient having developed a left hemiplegia. At post-mortem, the right common carotid, the right internal carotid, and the right middle cerebral arteries were found to be full of clot. Clotting may extend also from the sac into its distal branches by continuity. Similar considerations have been proved to exist, moreover, in the surgery of aneurysms affecting the limbs.

There is the additional disadvantage that ligatures placed on the proximal part of the vessel may fail to obliterate its lumen completely. This fact was demonstrated in two of the cases described, and was first reported by Thompson, who having tied a stay-knot on the innominate artery in a case of aneurysm treated by proximal ligature alone, found at post-mortem over two months later incomplete occlusion at the site of his ties. In such cases there was an added risk of embolism, both cerebral and brachial.

With a clearer conception of the causes of circulatory disasters following simple proximal ligation there would appear to be no possible argument in favour of its continued use in treatment, since the operation would be only slightly prolonged by tying off the two great branches close up to the aneurysm and nothing but advantage could be gained.

The sac in which it is hoped to produce consolidation is almost invariably situated at the termination of the main trunk or actually involves its distal branches, so that occlusion of the subclavio-carotid pathway is, in any case, a *sine qua non* if circulation of blood through the sac is to be prevented.

Sheen originally stressed the importance of closing the gateway for the passage of cerebral emboli by first ligating the common carotid. The risks of cerebral ischæmia, where there has been a pre-existing aneurysm, would appear to be slight in comparison, provided that the patency of the contralateral carotid has first been established. Since ligature of the carotid alone will fail to cure the aneurysm, one or both of the other trunks will be tied in addition, depending on the particular case.

The risks of cerebral vascular lesions attached to ligation of the common carotid artery have been variously estimated. Matas, with a personal experience of 80 ligations or band occlusions of the common and internal carotids, records 9 cases, or 11·2 per cent, in which grave cerebral disturbances occurred, and of these 6, or 7·5 per cent, died. Three others were saved only by the timely removal of the aluminium bands. He strongly recommends their use in doubtful cases, and has also employed systematic and methodical compression of the common carotid in the neck as a method of preparation of such patients for several weeks before operation. Pilcher and Thuss in a very complete review of the literature conclude that ligation of the common carotid artery will be followed by definite symptoms referable to the brain in some 20 to 30 per cent of cases, and that occasionally these symptoms will be serious enough to leave permanent residual damage, or, rarely, produce death.

In old patients, or those in whom doubt exists as to the adequacy of the cerebral circulation in the event of ligature of the common carotid, some temporary and readily removable occlusive agent is strongly advised. The following method, successfully practised by Mr. E. Rock Carling in a case of arteriovenous aneurysm of the cavernous sinus with pulsating exophthalmos, is a simple alternative to the use of metal clamps or bands as used by Halsted, Matas, and others. The carotid was exposed in the neck and a small length of rubber tubing of approximately the same calibre as the vessel was tied to it with broad tape. A slip knot was employed and this was so placed as to lie on the rubber tubing, the ends of the tape being allowed to protrude from the wound, which was loosely sutured. The method was absolutely effective, involved a minimum of trauma to the arterial wall, and

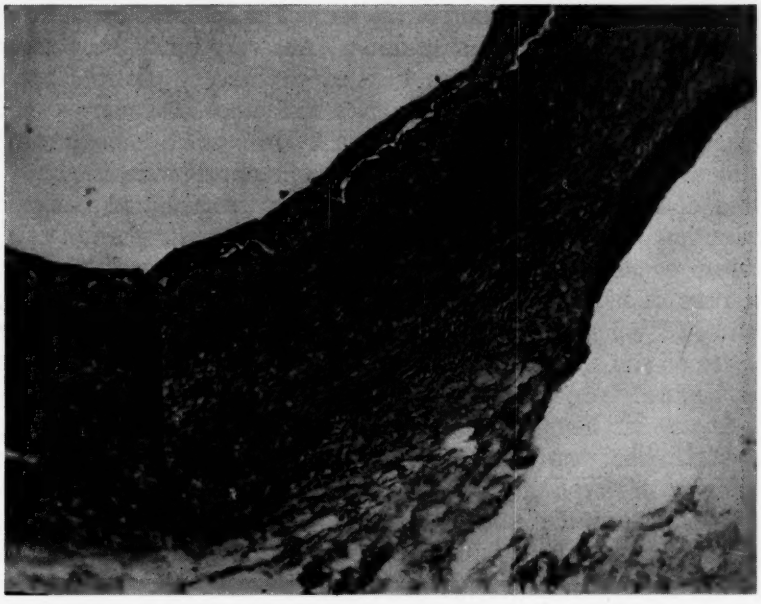


FIG. 140.—Microphotograph of section of a portion of internal carotid artery excised after 'temporary occlusion' for 4 days. It will be seen that although there is some disintegration of the adventitia, the media and intima have undergone no degeneration and there is no sign of thrombosis.

the tape could have been removed instantly had signs of cerebral ischæmia become manifest. Four days afterwards this segment of carotid was successfully excised, and histological examination failed to show any signs of intimal damage or commencing thrombosis (*Fig.* 140). The ideal would probably be to make such a temporary occlusion of the carotid trunk a first stage in every surgical attack on aneurysms of the innominate artery.

If the aneurysm is very large, involving the whole innominate trunk, or its origin from the aorta, double distal ligation of the carotid and subclavian arteries offers the best prospects of a low operative mortality and subsequent consolidation in the sac. Jacobsthal condemned the procedure; Ballance regards it with disfavour; but in practice, as shown in the table, it has given excellent results where the dilatation is confined to the innominate artery. In combined aortic and innominate aneurysms it would not appear to prolong life. The disadvantage of simply applying distal ligatures to the subclavian and common carotid arteries is

that where nothing else could be done the aneurysm would probably be either very large and thin-walled or have already involved the aorta. In the one case there would be a definite risk of precipitating rupture of the sac, in the other not much hope of arresting its progress can be entertained. That distal ligation alone may fail to arrest progress in the aneurysm is shown in *Case* 3. It is of particular interest that this should be so when the dilatation was confined to the innominate artery itself, and in the complete absence of subsidiary branches. If, however, clinical and radiological evidence show that the aorta is not affected, and if for any reason an attempt to expose the innominate trunk is considered inadvisable, then double distal ligation should certainly be given a trial.

If possible, full exposure of the aneurysm is indicated, so that its exact extent may be determined and as thorough treatment as possible instituted. This will be determined by the local condition of the sac. The common carotid must be tied in all cases. Brachial vascular complications have very rarely been recorded, and therefore the subclavian should also be tied to prevent possible recurrence of pulsation in the sac. In the common terminal saccular variety of innominate aneurysm the main trunk can, in addition, easily be secured, since the vessel itself is some 5 to 6 cm. in length, and if the left innominate vein is gently retracted downwards a double plaited silk ligature can be passed and its ends tied. It is of the utmost importance to ascertain at this stage that the portion of vessel tied is in a healthy condition, and that no traction is exerted on the aortic arch, as, apart from risks of hæmorrhage if its walls tear, sudden stoppage of the heart is prone to follow such traction. If the aneurysmal process is confined to the innominate trunk, and the aortic wall in relation to its origin is healthy, then every effort must be made to isolate the sac no matter how far the dilatation extends downwards.

An operation that can be done without difficulty on the cadaver and which seems feasible in this type of case is the following: After exposing the aneurysm and the aortic arch in the manner detailed below, the inferior thyroid vein is divided between ligatures and the left innominate vein gently retracted downwards. Arterial clamps are now applied obliquely to the aorta so as to occlude that part of its lumen in relation to the origin of its innominate branch. The latter is then clamped and cut across so as to leave, if possible, a short stump, which is then sutured in two layers. If the dilatation of the innominate is so extensive as to render this impossible, the wall of the aorta itself will be sutured instead. That such a plastic suture of the aorta can be undertaken successfully is shown by such a case as the following. The operation would depend entirely on the aortic wall being in a healthy condition, and this emphasizes the importance of thorough investigation of it and the aortic valves beforehand, both clinically and radiologically. Partially to clamp the aorta may seem a daring measure but

"Diseases desperate grown by desperate appliance are relieved, or not at all."

Case Report of Successful Suture of the Aorta.—

M. E-M., aged 31, female, was admitted on May 28, 1934, complaining of severe dysmenorrhœa. She also stated that she had suffered from "mucous colitis" since the age of twenty-one, but observation and investigation in hospital revealed no abnormality in the colon. It was decided to resect the presacral and inferior mesenteric sympathetic plexuses, the operation being undertaken on June 7 by Mr. E. Rock Carling. The abdomen was opened in routine fashion through a midline incision, the intestines were packed off, and

the peritoneum of the posterior abdominal wall was incised in front of the sacral promontory. The presacral nerve was dissected free from surrounding fat and some old tuberculous glands, and removed. In cleaning the aorta and the inferior mesenteric artery at its origin a small unnamed branch of the former required picking up. When this was being ligatured the artery forceps were inadvertently jerked upwards so that the vessel came away in their points, leaving a tear in the aorta itself. Hæmorrhage was very severe, but it was possible rapidly to control it by digital pressure above and below its source. In the short space of time required to apply this pressure effectively, the vessel wall had been split by the force of the escaping blood so that the hole to be closed was three-quarters of an inch long. The modified arterial clamps of Meyer were applied obliquely to occlude that part of the aortic lumen in relation to the tear, which was then sewn over with a continuous oo silk suture. When the clamps were removed no further hæmorrhage occurred, but for the length of about an inch the aortic lumen was seen to be constricted. It was estimated that its diameter at this point was diminished by a quarter of an inch. The operation was completed in routine fashion, and there were no immediate or remote post-operative sequelæ to suggest that any harm had come from the arterial repair. Incidentally, the advisability of always having fine silk, stored in paraffin, ready for immediate use as an arterial suture was forcibly demonstrated in this case.

Nothing more than the triple ligature operation need be done where the aneurysm is very adherent, the only disadvantage of leaving the sac in situ being the possible persistence or exacerbation of symptoms as contraction occurs and surrounding structures, involved in scar tissue, are distorted. That it is possible to ligate the three great arterial trunks without resultant ischæmia or gangrene may be explained by the fact that for a considerable period the dilated sac has offered a delayed and circuitous passage for the flow of blood, because of the large quantities of laminated clot adherent to its walls, resulting in the development of collateral anastomotic channels.

The ideal of treatment is manifestly to excise the sac after triple ligation, but attempts to do this would appear to be justifiable only if the aneurysm is small and not densely adherent, since otherwise the danger to surrounding structures outweighs the added advantage of total extirpation.

Technique of Exposure (*Figs.* 141, 142).—The technique used to expose the aneurysm in *Cases* 1 and 2 is given in some detail here, because it proved eminently satisfactory. It involves splitting the manubrium sterni.

Light general anæsthesia combined with local infiltration of the superficial tissue with ½ per cent novocain was preferred as the anæsthetic. The incision followed the line of the anterior border of the sternomastoid muscle downwards from the level of the cricoid cartilage over the sternoclavicular joint to the medial end of the 3rd intercostal space. Flaps of skin and subcutaneous fat were raised off the deep fascia medially and laterally, superficial vessels being secured and tied. The lower attachment of the sternomastoid was identified and divided, the muscle being retracted upwards. The tip of the index finger was then used gently to clear the connective tissue from the posterior aspect of the manubrium sterni in the midline. This was now divided in the midline to the level of the second intercostal space, using Lebsche's sternum chisel, the separation of the right upper quadrant being completed with bone forceps. Self-retaining retractors were inserted, and by blunt dissection an excellent exposure was obtained of the structures in the superior mediastinum, including the aneurysm and the three main arterial trunks. A No. 7 plaited silk thread was passed round the innominate artery, but not tied. The common carotid was cleaned down to its origin from the aneurysmal sac and divided between firmly tied silk ligatures. The subclavian

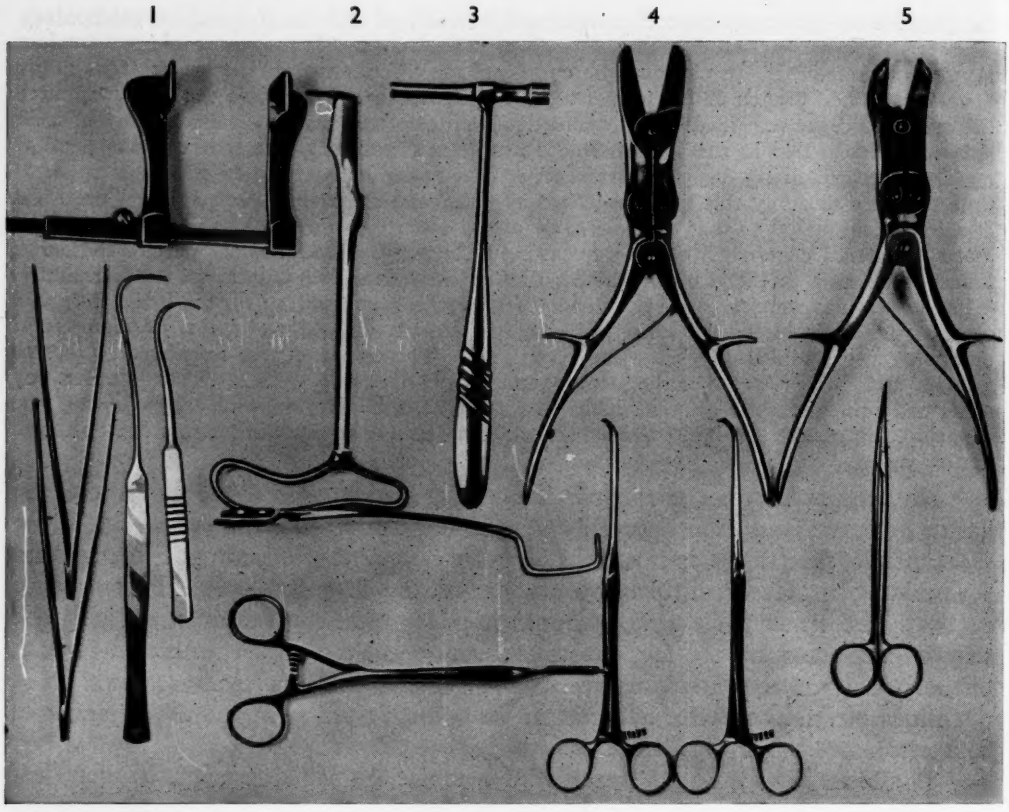


FIG. 141.—Special instruments used in the trans-sternal approach to the innominate artery in *Case* 2. 1, Tuffier's self-retaining retractors; 2, Lebsche's sternum chisel; 3, Hammer; 4 and 5, Bone-cutting forceps; 6, Long dissecting forceps, toothed and non-toothed; 7, Aneurysm needles; 8 and 9, Modified Meyer's arterial clamps; 10, Long blunt-tipped scissors.

artery was similarly treated at the point where it arose from the aneurysm, the vagus and its recurrent laryngeal branch being identified as the artery was cleared. The aneurysmal sac was now raised without much difficulty. The silk ligature on

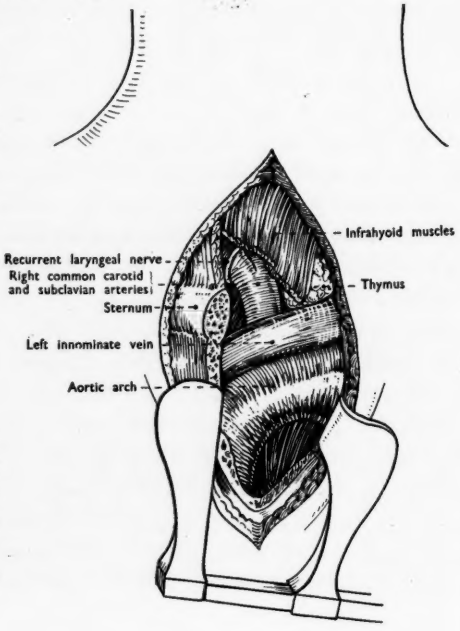


FIG. 142.—Showing the exposure obtained by splitting the manubrium sterni. The principal structures are named. The inferior thyroid vein has been divided between ligatures. Access to the origin of the innominate artery from the aortic arch is obtained by displacing the left innominate vein gently downwards.

the innominate trunk was tied as low down on the trunk as possible, and a second silk ligature applied just distal to it. An arterial clamp was placed on the artery beyond the ligatures and the vessel was divided along the distal border of the clamp. The divided

edges of the artery were then sutured with fine silk on a small round-bodied needle, the clamp being then removed. The wound was closed, the edges of the sternum being approximated with interrupted catgut sutures. A rubber drain was retained for twenty-four hours.

SUMMARY AND CONCLUSIONS

1. Three cases of aneurysm of the innominate artery are reported. In one a triple ligature operation was performed and in another the aneurysm was excised. Both patients were completely relieved and are still alive and well.

2. The pathological types of innominate aneurysm are discussed. The sac is almost invariably terminal in situation and involves the subclavian and common carotid arteries at their origin.

3. The clinical aspects and especially the investigation of the circulatory efficiency in the parts beyond the aneurysm are referred to; the necessity of examining the contralateral carotid artery is indicated.

4. If an attempt is to be made to ligate the innominate trunk it is essential to split the sternum; otherwise access is inadequate and the ligature may fail altogether to occlude its lumen. This is illustrated in two of the cases reported and in a third quoted from the literature.

5. Simple proximal ligation as a method of treatment is a most unsuitable procedure, because, while necessitating as thorough an exposure as the more complete operation, it gives the poorest results and is too prone to be followed by cerebral vascular complications.

6. Ligature of the three great trunks, innominate, common carotid, and subclavian, is essential to ensure cure of the aneurysm, which can then very occasionally be extirpated.

7. The common carotid and subclavian vessels must be tied in all cases. If doubt exists as to the efficiency of the cerebral circulation the aneurysm should be treated by a two-stage operation. At the first the right common carotid artery is exposed and its lumen occluded by a removable tape ligature tied over rubber tubing. The second stage is undertaken four or five days later, in the absence of cerebral complications, the sternum being split and all three vessels secured.

8. Distal ligature of the common carotid and subclavian vessels has a definite place in treatment, holding out a fair prospect of cure if the dilatation is confined to the innominate trunk. The operation is indicated where sternal adhesions are feared or when the general condition precludes a direct exposure of the innominate artery.

9. Combined aortic and innominate aneurysms are unsuitable for treatment by ligature operations, and should be regarded primarily as aortic in character.

10. The more extensive the dilatation in the innominate artery and the closer it approaches the aortic arch the more certain is it that cure will only follow if vascular communication between the two is interrupted. Under such circumstances the application of a ligature may be fraught with serious risks of fatal tearing of, or traction on, the aorta, and a technique of suturing the latter is described as a safer alternative. This is only indicated if the aortic wall itself is in a healthy condition, and every effort should be made to determine this before operation.

It is indeed a pleasure to record my great indebtedness to Mr. E. Rock Carling for his many helpful suggestions, his drawing of the exposure obtained by splitting the sternum, and his kind permission to publish the records of his cases. My thanks are also due to Mr. William Turner and Mr. Tudor Edwards for granting me the use of case records. I wish to thank Dr. R. J. V. Pulvertaft, Director of the John Burford Carlill Latoratories, for the free use granted me of post-mortem material, specimens, and sections. I am also grateful for the help given me in the Research Laboratory of the Royal College of Surgeons and to the library staff of the Royal Society of Medicine.

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CRITICAL REVIEW

THE TREATMENT OF PROSTATIC OBSTRUCTION OTHER THAN BY ENUCLEATION

By HUGH LETT, London

Various forms of treatment for prostatic obstruction other than enucleation have been practised from time to time, but most of them after a brief period of popularity have proved unsatisfactory and been discarded. There are three, however, which call for our special consideration—per-urethral resection, treatment by hormones, and the widely advertised Steinach II operation.

PER-URETHRAL RESECTION

Historical.—A hundred years have gone by since the first attempt was made to cure obstruction at the neck of the bladder by per-urethral methods. In 1834 Guthrie devised a urethrotome for incision of the bladder neck, and three years later Mercier went a stage further and introduced instruments which were designed not only to divide but to excise some of the obstructing tissue. Various modifications were made by other surgeons, but the position remained stationary until 1874, when Bottini proposed that the obstruction should be incised by the cautery blade. His instrument met with some success and was employed occasionally up to the end of the last century.

In 1909 Young introduced his well-known ' punch '. This was a great advance, but it did not prove to be entirely satisfactory, as it was found that if more than a small amount of tissue were excised, troublesome hæmorrhage might occur. The principle, however, was a valuable one; optical systems were added, and in 1920 Caulk substituted an electrocautery blade for the cold excising tube.

Meantime the surgical profession was gradually learning the possibilities of the high-frequency current, and in 1910 Beer advocated its employment for the coagulation and destruction of vesical papillomata. It was not long before its use was extended to cases of prostatic obstruction, and in this country Kenneth Walker so modified Young's instrument that the obstructing tissue was coagulated before it was excised. Other methods included coagulation by a series of needle electrodes introduced into the prostate, but this had the serious disadvantage of creating a large amount of dead tissue which remained until the sloughs separated and could be passed by the patient. The difficulty, however, has since been obviated by the introduction of the Braasch Bumpus punch.

Finally it was found that by raising the tension and frequency of the current, the skin and soft tissues could be incised by a fine electrode with a minimum of coagulation, and that extensive operations could be performed without the use of a scalpel. The importance of this discovery and the possibilities it offered in the treatment of prostatic obstruction were appreciated by urologists, and instruments

for resection of the prostate by the cutting current soon appeared. It is not necessary to refer to the many varieties which have been placed on the market, but it may be stated briefly that they all embody the principle of excision of the obstructing part of the prostate by the cutting current, and control of hæmorrhage by coagulation. In the instrument designed by Collins the excision is performed by a blade-shaped electrode, while in McCarthy's, which is the one most commonly employed in this country, it is done by a wire loop. Reference will be made later to the present tendency to return to the cold punch or galvanocautery for the actual resection, and to limit the use of coagulation to checking hæmorrhage from the larger vessels.

Per-urethral Resection by the Cutting Current.—Per-urethral resection by the cutting current was received with enthusiasm. It seemed that prostatectomy could be replaced by a simple and minor procedure, one that was associated with little shock and followed by such a short convalescence that patients could leave the hospital in a week or less. Such a prospect made a wide appeal, and the operation appeared to be so easy and straightforward that a large number of men who possessed only a limited experience of cystoscopy undertook it without hesitation.

But the glamour of " the moonshine and the roses ", to quote Bransford Lewis, soon began to fade in the critical light of dawning experience. Disturbing reports of deaths from hæmorrhage, ruptured bladders and extravasation, pelvic cellulitis and general peritonitis, apart from such sequelæ as serious infection of the kidneys, rectovesical fistulæ, and incontinence, showed its dangers and proved that it should only be performed by men who had a wide experience of cystoscopy and posterior urethroscopy. Indeed it was well said that to place a resectoscope in the hands of men who did not possess this experience might be compared to handing a submachine gun to a boy who was fresh from reading the stirring adventures of Deadwood Dick! But even urologists of experience found that the operation was attended by special difficulties; it was tedious and exacting, a highly developed technique and much judgement were necessary, and they soon learnt that only after performing it many times could they anticipate a general success and a low mortality. Alcock, for example, says that he did not feel that he was able to resect well until he had had the experience of 200 cases.

This operation has been on trial for some seven years; it has been practised very widely, particularly in the United States, and in 1934 Caulk was able to collect the records of no less than 15,448 cases, so that it is now possible to make a general assessment of its value, its limitations, and its dangers.

Dangers of the Operation.—Apart from those incidental to cardiovascular disease or failing kidneys, the dangers of the operation may be grouped under four headings: sepsis, hæmorrhage, excessive or wrongly directed coagulation, and the introduction of instruments that are too large for the calibre of the urethra.

Sepsis.—In the early days of resection attention was focused on three principal points—the immediate mortality, the occurrence of serious hæmorrhage, and the duration of the patient's stay in hospital. Fulminating pyelonephritis and the development of a fatal septicæmia were recognized as possible though rare complications, but little attention was paid to sepsis in its milder forms. Patients were sent home within the prescribed period, and in too many cases they then ceased to be under observation. Now, however, that the safety of the operation in competent hands has been established, and hæmorrhage is no longer regarded as one

of its principal dangers, the importance of sepsis has at last been recognized. Beer says that every series of cases in which a careful follow-up is maintained will show that pyuria, frequency, and dysuria often persist for months or may even be permanent. Such symptoms are to be expected if the resection has been inadequate, for micturition will remain difficult, the flow of urine restricted, and an appreciable amount of residual urine will persist.

But even if the operation has been carried out satisfactorily the urine will sometimes be purulent for a very long time. Chronic inflammation of the remains of the prostate, associated perhaps with chronic vesiculitis, is one of the most important causes, and such cases prove exceedingly troublesome and intractable.

Pyelitis or pyelonephritis will also give rise to persistent pyuria, and in this connection it is important to remember than an acute attack may develop during the course of the second or third week after the operation and prove fatal. When, however, the prostate is small and only a limited resection is necessary, frequency, discomfort, and pyuria are not so pronounced as a rule, and the urine generally clears up rapidly when the last slough has been expelled.

Acute epididymitis is a serious complication in feeble subjects, but it can be prevented by a preliminary vasectomy. If this little operation is not performed epididymitis will occur in a certain number of cases, the percentage varying perhaps with the skill and experience of the operator; for Kretschmer states that whereas it developed in 15 per cent of his first 117 cases, it has now become so rare that he finds a vasectomy no longer necessary and he has abandoned it.

When we consider the details of the operation of resection, the sloughs which are left behind, the frequency with which for some weeks after the operation there are several ounces of residual urine in the bladder, and the ready absorption of infection by the prostate, we can hardly wonder that sepsis so frequently occurs. Careful preparation and after-treatment are essential. Any existing infection of the urinary tract should be reduced to a minimum, and McCarthy among others recommends that the prostatic secretion should be examined and the prostate treated if necessary before resection is undertaken. Overdistension of the bladder must be avoided during the operation, and subsequently the greatest care must be taken to see that the catheter drains freely and does not become obstructed. Daily irrigation of the bladder should be carried out so long as the catheter is retained, and intravenous injections of cyclotropin or other urinary antiseptics have been recommended.

Hæmorrhage.—Hæmorrhage during or shortly after resection was at one time regarded as the most important complication. It certainly occurred with considerable frequency; blood transfusions were common, and a number of patients died; but serious uncontrollable hæmorrhage is now regarded as a rare event although it may still occur occasionally, even in the hands of the most experienced. The majority of resectionists proceed deliberately and coagulate every spurting vessel without delay, so that the total amount of blood lost is small, and this method has the further advantage of allowing the operation to be conducted under satisfactory vision. Some operators, however, when resecting a large prostate, work as rapidly as possible and do not attempt to check the hæmorrhage until they have removed the greater part of the obstruction, but this should only be practised by those whose skill and experience is of a high order.

In the event of troublesome oozing, compression by a Foley's catheter bag, which is placed in the prostatic urethra and then distended with water, has proved satisfactory, drainage being provided by a catheter which passes through the middle of the bag. It must be used with caution, as overdistension and traction may lead to temporary or prolonged incontinence.

Preliminary injection of adrenaline into the prostate gland, as recommended by Riches, has proved of considerable value, particularly in the resection of large prostates in old men who are not fit to undergo the operation of prostatectomy. There is no oozing, and consequently there is a clear field and spurting vessels are easily seen and controlled.

Excessive Coagulation.—One of the dangers associated with resection by the high-frequency current is the temperature which develops in the tissues underlying the area which is being treated. Extensive and repeated resections cause a great accumulation of heat, and the resulting tissue destruction will give rise to deep sloughing, so that injudicious treatment may lead to unfortunate results. In a

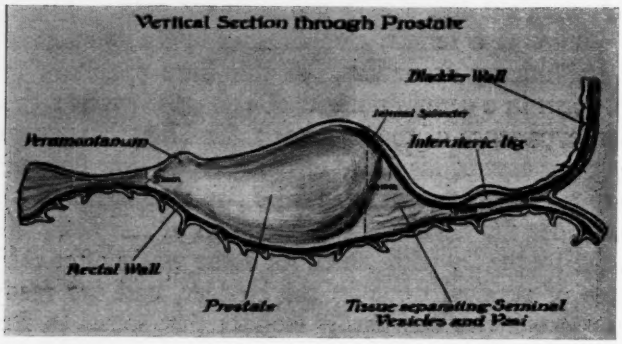

FIG. 143.—Vertical section through the prostate. (*By kind permission of the 'Journal of Urology'.*)

valuable paper Caulk reports certain experiments which demonstrated this rise in temperature at varying depths from the surface. He strongly advocates the use of the galvanocautery instead of the high-frequency current, as it causes superficial coagulation only and is not associated with any important rise in temperature in the underlying tissues, and he supports his contention by giving the results of a very large number of operations performed by these two methods. He found that sepsis and secondary hæmorrhage were twice as common after resection by the high-frequency current, while such complications as perforation, fistulæ, and incontinence occurred in the proportion of 4 to 1.

Kramer has recently conducted an investigation into the anatomical relations of the normal prostate and the trigone of the bladder to the surrounding structures. He has shown by means of serial sections on the cadaver (*Fig.* 143) that perforation of the bladder immediately above and below the inter-ureteric bar will open up the upper recess of Denonvilliers' space, and that as no structures are interposed between the bladder and rectum in this region the rectum is in serious danger. Below this level, as far down as the internal sphincter, it will also open up the space of Denonvilliers, but here there is little risk of injury to the rectum owing to the presence of the vesiculæ seminales, the vasa, and their ampullæ. Excessive or misdirected

coagulation in this area, therefore, may result in extravasation of urine and pelvic cellulitis, or at the least a pelvic abscess; while in the neighbourhood of the inter-ureteric bar, involvement of the rectum with a resulting fistula is likely to occur. The peritoneal reflection lies three-eighths of an inch above this bar, so that perforation at or above this level may be followed by peritonitis.

Apart from the possible complications already mentioned, excessive coagulation leaves deep and extensive sloughs which are a potent source of sepsis and secondary hæmorrhage, and increasing knowledge and experience have shown the importance of reducing the coagulation to a minimum. McCarthy has recently modified his instrument and now employs a cold punch for the excision of obstructing tissue at the bladder neck, limiting coagulation in this region to the control of important bleeding points only; the operation is then completed with the electrotome. He considers that as methods of catheter drainage and compression are improved, coagulation as a means of hæmostasis will be proportionately diminished, and consequently infection will be minimized.

Injury to the Urethra.—The calibre of the male urethra varies, and if it is appreciably smaller than the normal, it will not be possible to introduce the resectoscope without injury. Millin found that resection was inadvisable for this reason in 4 per cent of his cases. If the size of the urethra presents a serious difficulty, the operation must either be abandoned or carried out with a small resectoscope. This instrument, however, is not very satisfactory, and the operation becomes very tedious, as each piece of tissue removed is necessarily very small.

The forcible passage of an instrument that is too large for the urethra is a violation of one of the first principles of urinary surgery; it adds materially to the shock of the operation; and the patient is fortunate if he escapes with nothing worse than a slight laceration. Cases have been recorded in which peri-urethral hæmatomata have formed and even extravasation of urine has taken place. The ultimate development of a stricture is a recognized though rare complication of the operation, and it is one which gives little satisfaction to the patient.

Recurrence.—A further resection five or six days after the first operation is generally necessary when the growth is large or an inadequate amount was removed at the first attempt, but a true recurrence of the adenoma, such as was anticipated by some when resection was first introduced, is found to be rare if the operation has been performed by skilled and experienced hands.

A few cases of recurrence have been reported after resection of a median bar, and Randall suggests that such an event is not unlikely if the bar is due to posterior commissural hypertrophy. For in these cases there is great hypertrophy of the overlying trigonal and longitudinal muscles of the cervical lip in response to the obstruction caused by the increased glandular tissue, and as a result the latter lies so deeply that only a limited amount can be excised. In confirmation he points out that microscopical examination of the tissue removed by the resectoscope often shows nothing but muscle fibres, so that on clinical grounds they are sometimes called muscular bars. Recurrence occasionally follows transvesical operations in which the bladder neck has been divided or partially resected, and it is probable that the only certain cure of this condition is complete excision as practised by Marion. He reported a series of 69 cases in which he obtained permanent success, with the exception of one patient who was suffering from heavy infection at the time of operation and did not recover.

Unsuspected Carcinoma.—Microscopical examination has shown the presence of carcinoma in an appreciable proportion of specimens removed under the impression that they were adenomatous. The incidence of such unsuspected carcinoma varies from 10 to 20 per cent in different statistics, and its possible presence has been brought forward as an argument against resection; for the prognosis after enucleation is good, and Thomson-Walker reported that out of 66 cases he followed up in only 2 did the carcinoma recur. Further information is needed on the progress of these cases after resection.

Place of the Operation in Prostatic Surgery.—Per-urethral resection is unquestionably an operation of great value and one that is likely to have a permanent place in the treatment of prostatic obstruction. Remarkable results have been obtained in the United States by a few men who can show a mortality ranging from 2 to less than 1 per cent in series of cases numbering 1000 or more. They resect every case almost without exception; massive enlargement is no contra-indication, and Gershom Thompson reports a mortality of only 1·5 per cent in 200 resections in which the total amount of tissue removed varied from 25 to 80 grammes or more. But the brilliant success obtained by these master-resectionists must not blind us to the fact that it has only been obtained after long experience and by special skill, and that, in spite of improvements in technique and in the instruments at our disposal, per-urethral resection is not an operation to be lightly undertaken by all and sundry.

It is unlikely that resection will ever be regarded as the only operation for prostatic obstruction to the exclusion of all others, except by a very few men. There are many urologists in the United States who now limit resection to 25 or 30 per cent of their cases, and this corresponds fairly closely with the present practice of most of the urologists here and on the Continent. Kenneth Walker, who has employed various forms of per-urethral diathermy for some fourteen years, states that he now employs resection in 20 per cent; while Millin, who introduced resection by the endothermy loop into this country in 1930 and has an experience of over 400 cases, finds that although during the years 1932–33 he resected 90 per cent of his cases, he has employed this method in only 32 per cent during the last two years.

It is generally agreed that per-urethral resection is the method of choice in small middle-lobe enlargements, in the case of the fibrous prostate and sclerosis of the bladder neck, in median bars, in obstruction following prostatectomy, and in certain cases of carcinoma and prostatic calculi. In no instance is it of greater value than in old patients who are unfit to undergo prostatectomy, for with due care and special precautions many of them will pass safely through this operation, whereas suprapubic enucleation would prove fatal. In these patients it is advisable to carry out preliminary cystotomy and vasoligation, and to make repeated limited resections, rather than to attempt the removal of a large amount of tissue at one sitting.

Prostatectomy is still the most satisfactory operation in all cases of moderate or pronounced enlargement when the general condition of the patient is sufficiently good. The cure is complete, and sepsis leading to serious complications or prolonged discomfort is far less common than after resection. The mortality in comparable circumstances is no greater after prostatectomy than after resection, and it is probably less.

In early cases when the symptoms are very slight, when there is no trabeculation of the bladder, and no residual urine, resection should not be undertaken, for, as Day points out, the results are not satisfactory and the patients are usually made worse rather than better by the operation.

TREATMENT BY HORMONES

Much has been written on the anatomical origin of the enlarged prostate, on its pathology, and on the reasons for its occurrence. Until Jores stated in 1894 that middle-lobe hypertrophy arose from the peri-urethral glands lying at or near the neck of the bladder, it was believed that enlargement of the prostate always originated in the gland itself. Albarran, Motz, and Perearneau developed the work done by Jores, and came to the conclusion that lateral-lobe enlargement as well as that of the middle lobe arose exclusively from these peri-urethral glands. This theory was widely accepted, and they are still regarded by some as the source of all forms of prostatic hypertrophy. In 1907, however, Wallace pointed out that long before there is any alteration in the outlines of the prostate, the characteristic specks which later become nodules and are the precursors of prostatic enlargement can be found in the prostate itself, sometimes at its periphery. It therefore appears that prostatic hypertrophy may originate either in the prostate or the peri-urethral glands, and according to some authors the relative incidence is approximately equal. The suggestion that this condition may arise from two separate structures is at first a little disturbing, but, as Krogius has said, these relatively short and little developed accessory glands are very similar in their histological appearance to the glands of the prostate.

Pathology.—For many years the adenomatous or fibro-myomatous formation was regarded as a new growth or a true tumour, but in 1910 Paul, in an able paper to which too little attention has been paid, maintained that the evolution of the prostate was entirely controlled by the internal secretion of the testis, and that its enlargement was due, not to a neoplasm, but to a process of involution. Further, he drew attention to the close resemblance between the microscopical appearances seen in these cases and those in involution cystic mastitis.

It seems probable that prostatic hypertrophy is essentially the result of a hyperblastic regenerative and compensatory process, analogous in many respects to the regeneration which takes place in the normal prostate. But in the pathological condition the glandular proliferation is associated with a considerable increase in the stroma, so that, as mentioned above, the preliminary stages of prostatic enlargement can be recognized by the presence of small nodules resembling adenofibromata. This increase in the fibromuscular stroma is of great importance, for Krogius states that the new glands are lined by secretory epithelium and at first have excretory ducts, but that as the process develops the stroma compresses the ducts, dilatation of the acini and cystic formation follows, and this leads to the usual adenomatous type of enlargement. Excessive proliferation of the stroma, on the other hand, leads to the development of fibromyomata.

Ætiology.—The relation between the gonads and the secondary sexual organs has long been recognized, and in 1893 White tentatively discussed the possibility of treating prostatic hypertrophy by castration. To his suprise the suggestion was acted upon by a large number of surgeons, and a year later he was able to collect

111 cases in which the operation had been performed, when he found that a reduction in the size of the prostate was claimed in 87 per cent. It is notoriously difficult to estimate slight alterations in the size of the prostate, and the claims may not have been justified in every case; but a careful scrutiny of the reports shows that in approximately one-half of the cases the diminution was indeed remarkable, and in 5 of them the prostate was reduced to a small flat mass or was no longer palpable.

A little later Cabot reviewed 203 cases, including those published by White, and came to the conclusion that in some cases enormous shrinkage takes place, and that in large soft prostates, especially if the lateral lobes were mainly involved, relief could be expected with considerable confidence. A pronounced middle lobe or a large intravesical projection made improvement more doubtful, and none at all could be expected in the case of the fibrous or fibromyomatous prostate. His findings are of interest in connection with the prostatic hypertrophy which occurs so frequently in dogs. In them the prostate may attain a great size and fill the pelvis, but it is smooth and uniform in outline and there is no middle-lobe enlargement. Professor McCunn kindly informs me that castration is commonly practised with good results.

Castration in the human subject, however, had but a short vogue. It is essentially a mutilating operation; serious mental disturbance followed in some cases; it was only successful in a certain type of prostate; and Cabot found that it proved fatal in 39 of the 203 cases, a mortality of 19·4 per cent; but it is proper to state that the operation was performed on many patients who were so gravely ill that they were quite unfit for it. So it fell into disfavour, and was finally abandoned when suprapubic prostatectomy was established and Freyer was able to report in 1904 that he had operated upon 107 cases with only 10 deaths.

The great progress of endocrinology and biochemistry has inevitably led to attempts to solve the problem of the association between the testis and prostatic enlargement. Many experiments have been performed on many animals, a vast literature has accumulated and various theories have been presented, but the connection between the testicular function and the prostate is not yet entirely explained. It seems probable that the male hormone proper is secreted by the interstitial cells of the testis, and that this hormone is the main factor in the development and control of the prostate. Some consider that benign enlargement is due entirely to a diminution in the secretion of this hormone as age advances. Others postulate the presence of a second hormone, arising from the seminiferous tubules and which they call inhibin. They believe that it controls the gonadotropic activity of the pituitary gland, and that as in the age of involution the tubular cells of the testis become diminished in number less inhibin is formed; the pituitary then becomes hyperactive, and as a result there is excessive stimulation of the interstitial cells of the testis, which in their turn produce the prostatic enlargement. Whether there is such a hormone as inhibin or not, for it has not yet been isolated, there is evidence which seems to suggest that the pituitary gland plays a part in the benign changes that may occur in the prostate at and after middle age.

Lower and McCullagh, who advance the inhibin theory, claim that by giving an extract of testicular substance equivalent to 60 grammes of the testis of an ox they have relieved the symptoms in 63 per cent of 76 cases, and say that almost equally good results have been obtained by other medical men to whom they have

sent supplies of the extract. Complete or partial retention entirely disappeared or was reduced to a minimum, and the act of micturition became normal. They express the opinion that the treatment is most likely to be effective in the case of soft adenomatous prostates, but add that in no instance did the gland become smaller, and in successful cases it was found advisable to give a modified course of treatment from time to time in order to prevent a return of the symptoms.

Hamilton, Heslin, and Gilbert question this theory. It has been shown that the female sex hormone inhibits the action of the pituitary gland, and they therefore treated 9 men suffering from prostatic enlargement by injection of œstrone. Their results were negative, and accordingly they suggest that the improvement in Lower's cases was not due to pituitary inhibition.

In an admirable review Zuckerman gives his reasons for believing that the male organism secretes an œstrogenic substance as well as the male hormone proper, that the normal balance between the two is disturbed in certain individuals at the prostatic age, and that as the œstrogenic substance becomes predominant it gradually gives rise to prostatic enlargement. He refers to the changes produced in certain animals by the administration of œstrone, and the fact that in the human subject the prostate is often considerably enlarged at birth, and shows an epithelial metaplasia which suggests that it is due to the large amount of œstrone present in the circulation of the mother (Burrows). Finally he draws attention to recent work which shows that some of the compounds of the androsterone-testosterone series are œstrogenic. The theory is an attractive one, and Zuckerman has recently published a paper with Groome in which they describe an unusual specimen of spontaneous enlargement of a dog's prostate which showed changes corresponding to those produced experimentally by œstrogens. The importance of their observation lies in the fact that it seems to prove that prostatic hypertrophy may occur spontaneously as a result of œstrogenic stimulation. The work of Krogius, which shows the important part played by the proliferation of the fibromuscular stroma in the early stages of prostatic enlargement in man, is of interest in this connection, for increase in this tissue is one of the principal changes that follow the experimental administration of œstrone to animals.

On the other hand, Hamilton and his fellow workers found that the administration of œstrone to prostatic patients caused no aggravation of their symptoms, as might perhaps have been anticipated if œstrogenic substances were the essential cause of prostatic enlargement.

A great advance has been made in our knowledge of the chemistry of the male hormone. The recent synthetic preparation of testosterone is of the first importance, and a great deal has been learnt about its potency and the duration of the effects of its various compounds. There are indications that testosterone proprionate may be of considerable value, but much careful work must be done before its real worth in the treatment of prostatic enlargement can be finally determined.

We are still groping in a dim light if not actually in the dark, but the relief of symptoms which Lower and McCullagh obtained in their cases by the administration of whole testicular extract is suggestive, and it will be most interesting to see whether the administration of testosterone proprionate alone will be able to produce similar or even more striking results.

THE STEINACH II OPERATION

This is a modification of the operation of vasoligation originally advocated by Steinach as a means of rejuvenation. He now claims that while ligature of the vas leads to a greater production of the internal secretion of the testis and a corresponding increase in the amount of the testicular hormone in the circulation, a still more powerful effect is obtained if the ligature is placed round the vasa efferentia as they leave the testis. The latter procedure is known as the Steinach II operation.

Niehans has adopted it as a method of treating prostatic enlargement, and states that he has given relief to more than 400 patients. It is regrettable, however, that with the exception of 3 or 4 cases he does not appear to have published any details, and he merely makes the general statement that as a result the patient " once more empties the bladder without effort, the stream becomes more forcible, and in the majority of cases the residual urine entirely disappears ".

The operation was discussed at the meeting of the Société française d'Urologie in 1933, when Fey and Dossot were able to present a collection of 35 cases operated upon by various surgeons. In 13 the results were more or less good, but Fey and Dossot point out that in all of them the operation was combined with regular or intermittent catheterization, irrigation of the bladder, and so on, and consider that they merely represent the usual proportion in which palliative treatment is followed by improvement. Pettavel reported 8 cases of his own and collected 33 others that had already been published. He believes that, while some early cases benefit functionally, the improvement is often transient, and in chronic cases the failures far outnumber the successes.

Papin, in a sarcastic and highly entertaining paper entitled " Le Déconfiture de l'Opération dite de Steinach (tous numéros) ", comes to the conclusion that while the operation produces signs of rejuvenation, unquestionably acts on psychic disturbances, and may afford temporary relief by diminishing congestion, it cannot modify the anatomical lesions of prostatic hypertrophy. He adds that many surgeons who have performed the operation have observed no improvement, and, further, that they have had to carry out prostatectomy on numerous patients who had previously undergone the Steinach II operation at the hands of others.

On the other hand, Elliot-Smith describes his results in 20 cases in a paper which is of particular importance, as it contains details of the condition and progress of the patients before and after operation. In 2 of them the retention recurred and prostatectomy became necessary, 2 could not be traced, and 3 died four or five weeks after the operation. All the patients had been admitted for retention and had had continuous or intermittent catheterization for varying periods; in 4 a little urine was passed before the operation, but the remainder still had complete retention. In 5 of the 20 cases voluntary micturition returned on the day of operation; in one of them there had been complete retention for five weeks, and twenty-four hours later only 2½ oz. of residual urine were found in the bladder. In all of his cases the prostates were large. He was able to keep 13 patients under observation for periods ranging from one to eighteen months, and the most striking features in their subsequent progress were absence of difficulty in micturition, a diminution though not abolition of nocturnal frequency, and a fall in the residual urine to amounts varying from ½ to 3 oz., with the exception of one case in which it amounted to 10 oz.

His results are chiefly remarkable for the sudden restoration of voluntary micturition in five of the twenty cases, and for the relief of certain subjective symptoms such as nocturnal frequency and difficulty in micturition. But although they are suggestive, the relatively small number of his cases does not justify any general conclusion as to the immediate results of the operation, and the patients had not been under observation long enough to enable any idea to be formed as to the permanence of any improvement that may follow it. Even in the short period which elapsed between the operation and the time of the report, two of the fifteen cases which survived and could be traced had had a further attack of retention and the prostate was removed.

It is difficult to assess the real value of the Steinach II operation and the place it should occupy in the treatment of prostatic enlargement. Little help can be obtained from the literature, as, with the exception of Elliot-Smith's series, the cases published by individual surgeons are few in number and details are often lacking. But it is perhaps significant that the numbers reported by them are so small, for it suggests that their experience of the operation has not been happy and that they have not felt encouraged to continue to practise it.

The balance of evidence suggests that the operation may occasionally relieve symptoms to some extent when the prostate is large and adenomatous, and in a few cases of retention it appears to have had a dramatic effect within a few hours. There is, however, no satisfactory evidence that it can cause any reduction in the size of the prostate, and there is a considerable probability that after a time the symptoms will recur. Further, the practice of this operation may lead to serious delay if the kidneys are already affected or if the prostate is the site of unsuspected carcinoma.

It has been suggested that it should be undertaken as a prophylactic against prostatic enlargement, but in the present state of our knowledge this is entirely unjustifiable and should be strongly deprecated.

In view of the doubtful value of this operation and its extensive advertisement among the laity, it is desirable that reliable statistics of its effect in a large number of cases should be obtained. At the moment we are not concerned with the various hypotheses which have been put forward to explain any action it may have had on the prostate in some cases, whether by increasing the available hormone, by acting on the sympathetic, or merely by relieving congestion; it is first necessary to ascertain how far the claims which have been made for it can be substantiated.

In considering indirect methods of treatment it is important to remember that the symptoms of prostatic hypertrophy do not always steadily and progressively increase, but that they vary from time to time, particularly if the prostate is large and adenomatous. It is generally recognized that congestion is the great danger to which the prostatic subject is exposed. It may be brought on by alcohol, overfeeding, a chill, and so on, and may then persist for weeks, leading to frequency, difficulty, and in some cases to retention. Many patients improve under appropriate general treatment combined when necessary with catheterization.

When the lateral lobes only are involved, the patients are usually entirely free from symptoms apart from occasional attacks of retention at long intervals, and between these attacks they have no frequency, no difficulty in micturition, and there is no residual urine. At this point reference may be made to a case reported by Chevassu. The patient had suffered from almost complete retention for several

weeks, and finally the Steinach II operation was performed combined with prolonged drainage by catheter. Normal micturition returned and the residual urine fell to 30 c.c. The case was regarded as a brilliant success and a triumph for the Steinach II operation, but unfortunately two and a half years later the patient had another attack of retention. Prostatectomy was performed, and at the operation two large masses were enucleated. The lateral lobes only were involved, and there was no middle lobe enlargement. This case was typical of those in which an occasional attack of retention is to be anticipated with complete absence of symptoms between the attacks, and the Steinach operation received credit to which it had no claim. Incidentally, microscopical examination showed no variation from the normal appearances of an adenomatous prostate, while urethrograms, cystograms, and rectal examination showed that during these two and a half years there had been no diminution in the size of the gland.

We must also bear in mind the possible psychological effect of an operation or the exhibition of hormones, especially in early cases and in nervous patients who are obsessed by the fear that their prostate may enlarge.

It is a matter of some interest that whereas until now removal of the testicles is the only procedure that has caused a definite reduction in the size of the human prostate, the present trend is to attempt to bring about this reduction by adding to the patient's supply of testicular hormone. Whether this will prove to be possible or not we cannot say. If the enlargement were due to a simple glandular hypertrophy ultimate success might perhaps be anticipated with some confidence, but can we reasonably expect masses of adenomatous or fibromyomatous tissue or both to disappear under this treatment? The prospect is dubious, but the reduction in the size of large adenomatous prostates after castration and of uterine fibromyomata after oöphorectomy offers some encouragement, and suggests the possibility that similar results may perhaps ultimately be obtained by endocrine treatment. But in view of the results obtained so far it seems improbable that in its present form it will ever cure obstruction caused by a fibromyomatous prostate, and it certainly cannot be expected to have any effect on the small fibrous variety associated with contraction of the bladder neck.

CONCLUSIONS

Prostatectomy is still the operation of choice in moderate and large hypertrophies.

Per-urethral resection is valuable in the case of contracture of the bladder neck, small obstructions, certain cases of carcinoma, and, with special precautions, in feeble patients with large prostates who are not suitable for prostatectomy.

The Steinach II operation may give some relief from symptoms under certain conditions, but its effects appear to be transitory, and by delaying prostatectomy it may be responsible for serious consequences.

Treatment by hormones, though still in its infancy, seems to hold out a promise of relief in early cases and in those in which the prostate is large and adenomatous. But real progress can only be made in this, as in so many other branches of medicine and surgery, by close co-operation between clinicians and workers in the laboratory. A full and detailed account of the previous history of the patient, and skilled urological observation to determine among other things the type and configuration of

the prostate before treatment, and whether any alteration takes place after it, are essential. In no other way can this treatment be based on the sure foundation of fact and a proper estimate of its value be obtained.

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EXPERIMENTAL SURGERY

LESIONS IN A RABBIT'S LIVER AND SPLEEN FOLLOWING AN INTRAVENOUS INJECTION OF THOROTRAST

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THORIUM dioxide, in the form of thorotrast, has been strongly recommended as an adjunct to radiography on account of its opacity to X rays. Apart from its introduction into the bladder, renal pelvis, and other natural cavities of the body, and into fistulous tracts to facilitate their demarcation, thorotrast is injected into the blood-stream to obtain clear silhouettes of the blood-vessels, the spleen, and the liver. Given in this way thorium dioxide becomes segregated in the reticulo-endothelial cells of the liver and spleen (Kadrnka), and to a less extent in those of the bone-marrow (Baumann and Schilling). Both in man and in rabbits immediate morbid sequelæ have followed such injections. In rabbits extravasations of blood in various internal organs have been seen, and are attributable, according to Shih and Jung, to an acute thrombocytopenia. In man, headache, malaise, pyrexia, vomiting, and hæmorrhages have been noted as early sequelæ (Stewart, Einhorn, and Illick).

The experiment about to be described was undertaken to observe whether any later ill effects might follow an intravenous injection of thorium dioxide. This substance is radioactive, and is eliminated very slowly if at all. In these circumstances there seemed to be a danger that in the course of time neoplasia might be induced. The experiment was as follows:—

In December, 1931, 2 c.c. of thorotrast (containing 0·5 g. of thorium dioxide) were injected into the marginal ear vein of a rabbit weighing 1900 g. This dose is not greatly disproportionate to that recommended for man, namely, 40 to 100 c.c. After this single dose no further treatment was given. The rabbit died in July, 1936. Radiographs taken immediately after the injection and again after the animal's death show that, in the intervening period of 4½ years, little if any of the thorium has been eliminated (*Figs.* 144, 145).

The following conditions were found post mortem: The peritoneal cavity was distended with sanguineous fluid. The pale, enlarged liver weighed 265 g., and was studded with innumerable red masses of various dimensions. The spleen was small, weighing 3·5 g., and it contained red, rounded masses similar to those in the liver (*Fig.* 146). The largest of these can be recognized in the radiograph (*Fig.* 145). A few cubic centimetres of clear fluid were present in the pleural cavity; and sparsely scattered over the surface of the lungs, pleural surface of the diaphragm, and parietal peritoneum were several raised red nodules, mostly one to two millimetres in diameter, resembling vascular nævuses. All the other

organs, including the heart, appeared healthy. The red masses in the liver and spleen, examined microscopically, are found to consist mainly of extravasated blood, most of which seems to have escaped recently. In some areas the blood has clotted and undergone other changes—partial decolorization and infiltration with

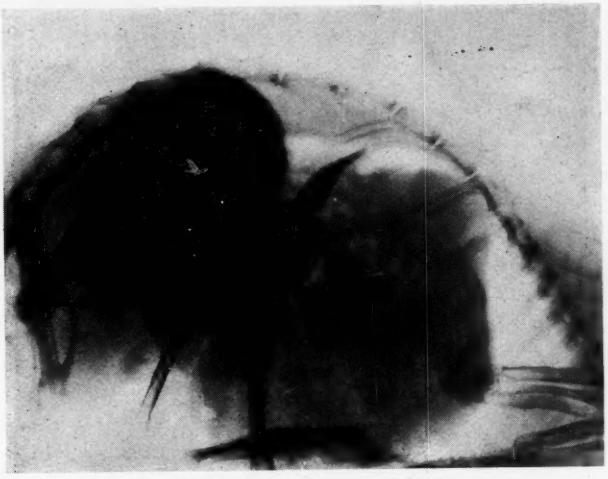

FIG. 144.—Radiograph of rabbit taken 3 months after injection of 2 c.c. of thorotrast.

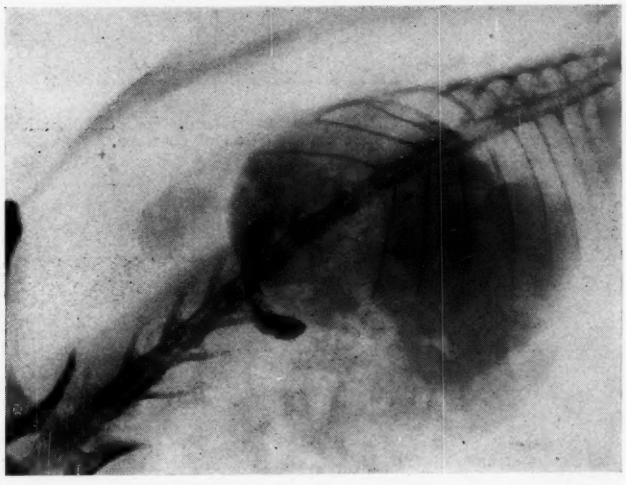

FIG. 145.—Radiograph of same rabbit 4½ years after injection. Note the outlining of the trabeculæ of the spleen and of the lesion shown in the coloured plate.

leucocytes—which suggest that it had been effused some days perhaps before death. Associated with these lesions are dilated, thin-walled blood-vessels which appear to have been the sources of hæmorrhage. The nævus-like lesions of the pleura and peritoneum consist of one or more greatly dilated thin-walled blood-vessels (*Figs.* 147, 148). In some places the parenchyma of the liver appears normal, in others there is considerable vacuolation of the cytoplasm, with disappearance of

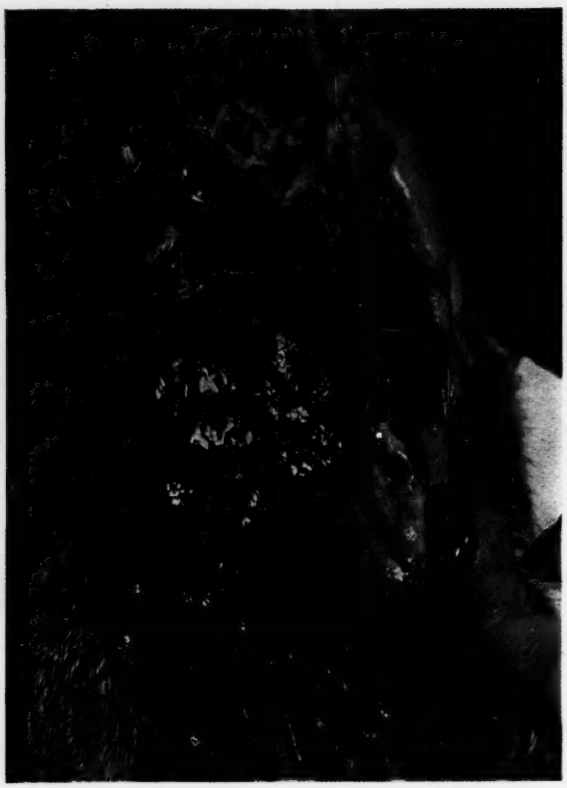

FIG. 146.—Showing hæmorrhagic lesions in the liver and spleen. The discoloration of the stomach is due to post-mortem digestion of its walls.

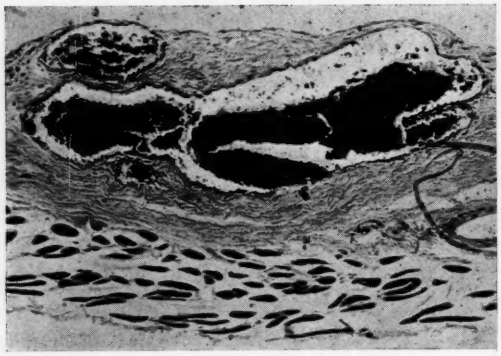

FIG. 147.—Microscopic section of diaphragm, showing greatly dilated thin-walled blood-vessel in pleural layer. (× 36.)

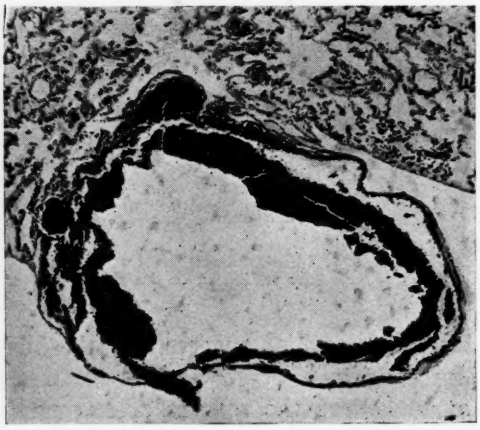

FIG. 148.—Lesion similar to that shown in *Fig.* 147, on surface of lung. (× 36.)

the nuclei (*Figs.* 149, 150). Granular material, presumably thorium, is present in close association with individual Kupffer cells. In other places the hepatic sinusoids contain aggregates made up of granules and detached Kupffer cells (*Figs.* 149, 150). But the largest collections of granules in the liver are free from any visible cells and occupy spaces—whether veins or lymphatics is uncertain—in the interlobular stroma close to the hepatic venules and small bile-ducts (*Fig.* 149). These appearances may be taken as evidence that thorium dioxide is not retained indefinitely by the Kupffer cells in the hepatic sinusoids. The most abundant deposits of granular material are in the trabeculæ of the spleen, the lobules of which are atrophic and almost free from thorium (*Fig.* 151).

FIG. 149.—Interlobular septum in liver showing bile-duct, artery, and vein. The large dark masses presumably are collections of thorium. In some of the sinusoids are aggregations of detached Kupffer cells and granules of thorium. (× 90.)

FIG. 150.—An hepatic sinusoid containing a mass of detached Kupffer cells and granules of thorium. Vacuolation is shown in some of the liver cells abutting on the sinusoids. (× 300.)

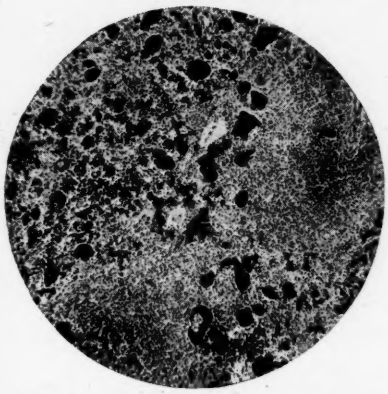

FIG. 151.—Spleen, showing trabeculæ loaded with collections of thorium (shown as black masses). Two atrophic lobules are shown. (× 36.)

DISCUSSION

The precise nature of the condition found in this rabbit is not easy to determine. The lesions consist of greatly dilated, thin-walled blood-vessels, from many of which blood has been extravasated. These primitive-looking blood-vessels are not accompanied by any undifferentiated cellular growth which might be described as neoplastic (*Figs.* 147, 148). It does not seem possible to account for the lesions by a primary focus of phlebitis with secondary emboli; the condition appeared to have originated in the liver and spleen. Until the histological preparations were examined the condition had been thought to be malignant. The peculiar distribution of the lesions is difficult to explain on any other basis. However, the histological appearances do not in any way suggest the presence of malignant neoplasia.

Since this experiment was begun, Oberling, Guérin, and Roussy have shown

that the subcutaneous or intraperitoneal injection of thorium dioxide may induce sarcoma in rats. In one of their series sarcomata appeared in 8 out of 10 rats so treated and surviving for ten months or longer, and in a second series sarcomata developed in 8 out of 15 rats treated in a similar way and living for a year or more afterward. The dosage used was large, but the results point clearly to a danger accompanying the injection of this radio-active substance into the body. Their observations have been confirmed in this country by Selbie.

That radio-active materials introduced into the tissues can bring about neoplasia both in man (Martland) and in animals (Daels and Biltris, Ross and others) has of course been well established. Although the radio-activity of thorium dioxide is slight, it may yet be enough, after therapeutic administration in man, to cause an image of the spleen to appear by its own radiations on a photographic plate (Stewart, Einhorn, and Illick). As our experiment shows, once introduced, the elimination of thorium dioxide may be so slow that little has occurred during $4\frac{1}{2}$ years—a period in which a minute amount of continued irradiation might perhaps be sufficient to cause neoplastic or other advanced pathological changes. Whatever the lesions may have been in our experimental rabbit, there can be little doubt that they are attributable to the thorium and that they caused the animal's death.

Many clinicians have come to regard the use of thorium dioxide with some distrust, but this distrust is not universal. Yater, Otell, and Hussey in a recent paper go so far as to "predict that hepatosplenography with stabilized thorium dioxide solution will come to be recognized as a valuable and eventually harmless diagnostic procedure". This prediction is based on a follow-up of 200 cases in which the method was used for clinical purposes. The average dose was 75 c.c., but some patients received as much as 100 c.c. The longest period elapsing between the injection and the final examination was under five years, a period in our opinion too brief to eliminate the possibility of ultimate disaster.

SUMMARY

1. Two cubic centimetres of thorotrast, containing 0·5 g. of thorium dioxide, given intravenously to a rabbit, became concentrated in the liver and spleen, where it remained without obvious diminution during $4\frac{1}{2}$ years.

2. The rabbit died from multiple hæmorrhagic lesions in the liver and spleen, presumably induced by the thorium dioxide. The precise nature of these lesions remains uncertain.

I am much indebted to Professor J. M. W. Morison for his advice and interest in this experiment.

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INTESTINAL STRANGULATION

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In a recent publication[1] the results of an experimental investigation of the pathology of intestinal strangulation were reported. It was shown that in cats the amount of fluid lost from active circulation as the result of peritoneal exudation, stagnation in the strangulated loop, and loss into the lumen of the affected segment, was in no case sufficient to account for the circulatory collapse and death of the animal. This result, obtained by gravimetric methods, was confirmed in the case of strangulated segments affecting long loops of intestine, by cross circulation experiments. These showed that an animal supplying blood to a strangulation of the entire small intestine of a second animal, remained unaffected by the fluid loss into the affected area, whereas the survival of the animal whose gut was strangulated was not prolonged, despite the elimination of fluid loss. It was therefore concluded that even in very long loops fluid loss plays no more than an accessory role in the production of circulatory collapse, which is due, in the main, to other factors which must be nervous or chemical.

In searching for evidence of the production and absorption of toxic substances, it was shown that within one hour of the onset of experimental strangulation a substance, or more probably a mixture of substances, capable of producing a depression of blood-pressure, appears in the veins and lymphatics of the strangulated loop. On injection intravenously in the normal animal blood and lymph derived from this source produced variable reactions—in a few cases a rise of blood-pressure occurred, but in the majority of cases the reaction was depressor.

Following the initial fall in blood-pressure, the further character of the tracing varied. With small doses the pressure returned to its original level; with larger doses, however, this recovery did not take place, but instead the pressure returned slowly and remained stable at a permanently lower level.

In many cases during the recovery phase the pulse was observed to be slow and irregular. The presence of numerous dropped beats suggested that the substance or substances present in the fluid under examination had a toxic action on the heart. The three reactions obtained—occasional pressor reaction, depressor reaction, and cardiac irregularities—were attributed by us to the presence in the blood and lymph of substances derived from the tissues of the gut wall as the result of catabolic changes consequent upon the anoxæmia. The early appearance of these substances in a series of experiments conducted with the bowel lumen freely irrigated, and containing only saline, appeared to us to exclude a bacterial origin.

It was shown that these substances are capable of dialysis and may be absorbed into the circulation in one of two ways. Before the relief of the strangulation they exude into the peritoneal cavity, their appearance here being governed by the severity of the strangulation, and hence the permeability of the gut wall. As the

strangulation increases in severity, the depressor substances make their appearance in the peritoneal exudate and are absorbed into the circulation, in part at least, via the thoracic duct. Secondly, following the relief of the strangulated segment, the depressor substances contained in the veins and lymphatics of the strangulated loop are set free and enter the circulation. It was shown that following the relief of experimental strangulation, a deterioration of the animal's condition occurred, which we attributed to this reabsorption, and it was suggested that a similar process occurring in a human patient whose circulation was already depressed as the result of previous toxic absorption might have harmful results.

Distension of the strangulated segment of intestine was shown to be an ancillary factor of great importance in the production of the circulatory collapse, since it was found that rhythmic distension and relaxation of a loop of normal intestine can, by itself, produce a decline in blood-pressure. This result is in agreement with the work of Taylor, Wild, and Harrison,[2] who, in a classical series of experiments, by introducing a rubber tube surrounded by a balloon into the intestinal lumen, were able to cause distension of the gut without obstruction. X rays demonstrated the passage of barium meal through the tube, but on distension of the balloon to a pressure of 100 mm. Hg the animals succumbed in 48 hours with all the symptoms of experimental strangulation. These observers concluded that the distension produces this result through a nervous mechanism. Distension to a pressure of 100 mm. Hg, however, must necessarily cause venous occlusion, stagnation, and anoxæmia in the gut wall—in fact, certain of the characteristics of strangulation—so that the decline in blood-pressure may be due to the production and absorption of depressor substances.

The conclusions of Aird[3] lend support to this view. In his series of experiments it was found that, following the release of a long-maintained distension of a segment of normal intestine (8-hour period or more), a decline in blood-pressure resulted. From this he not only inferred that toxic substances had entered the circulation, but also expressed the opinion that such a re-entry might be harmful in a toxic human patient, and suggested the advisability of resection of severely congested gut in such cases, to protect the patient from these influences. In other respects his conclusions show certain points of difference from our own. In relation to the strangulation of long loops of intestine he concluded that the volume of fluid lost from the circulation is alone sufficient to account for death, supporting the previous observations of Holt[4] on this subject, although, as we have pointed out elsewhere,[5] his experiments are vitiated by the introduction into the peritoneal cavity of a rubber bag in order to collect the fluid. This gives an unduly high record, firstly by preventing the normal process of absorption, and secondly by exciting a great increase in the outpouring of fluid as the result of the mechanical irritation of the foreign membrane. In relation to the source and mode of production of the toxic substances he further stated that these are of two groups, firstly a small concentration of such substances as histamine produced in the early stages, but reinforced later by the bacterial action of anaerobic organisms on the devitalized tissues of the strangulated area.

In continuing the investigation of the numerous problems connected with this subject, there are obviously four which require further elucidation :—

1. In view of the conflicting results obtained in long-loop strangulations, to inquire whether the volume of toxic substances produced during the short survival

period shown by these cases is sufficient to account for the circulatory collapse when acting alone, or whether, in the case of such massive experiments which can only attempt to reproduce the clinical picture of mesenteric thrombosis, the cause of death is not due, in part at least, to shock. If such is the case, since fluid loss is excluded by the cross circulation experiments already referred to, the nervous mechanism, the importance of which was emphasized by Slome and O'Shaughnessy,[6] must be carefully investigated.

2. To analyse by biological and biochemical procedures the various fluids obtained from strangulations at different periods and of varying degrees of severity, in order to determine the nature and potency of the depressor substances contained in them.

3. To investigate further the effects produced by relief of a series of viable strangulations of known severity upon the general condition of the animal. In cases where the gut is frankly non-viable, resection or exteriorization is naturally the only feasible procedure in treatment, but it has been suggested that a major procedure may be indicated in certain cases where the gut viability is not impaired. Before advocating such a measure, far more must be known of the possible action of any depressor substances released into the circulation by simple relief of the strangulation, and if possible definite pathological or clinical criteria established to indicate when these effects are to be expected.

4. To search for actual evidence of the presence of depressor substances in the peritoneal fluid or gut blood obtained from human cases of intestinal strangulation.

The first two points are the subject of continued investigation in the laboratories of the College of Surgeons by Dr. W. d'A. Maycock, and will be reported on in a subsequent paper. The present communication deals only with the latter two.

RESULTS OF RELIEF OF EXPERIMENTAL INTESTINAL STRANGULATION

A series of twenty experiments were performed. The loops were prepared in the following manner. Under ether anæsthesia and full aseptic precautions, a portion of small intestine at about the middle third was selected and measured. Obstructing ligatures were tied lightly around the gut at the ends of the selected segment in order to obstruct the lumen without cutting into the gut wall. The ends of these ligatures were left long in order to anchor a rubber band, which was then placed to surround the gut and mesentery of the selected loop. The tension on this band was then adjusted until the required degree of distension of the mesenteric veins was observed, the ends of the band then being stitched together. By alteration in this tension in different cases varying degrees of strangulation were produced. At a known interval after operation the animal was again anæsthetized with chloralose, 60 mg. per kilo, and a continuous blood-pressure record obtained by carotid cannulation. When the blood-pressure had fully stabilized, the abdomen was opened through the original incision, the rubber band and ligatures were divided, and the wound was closed. The record was continued for some hours until the animal's condition had again fully stabilized. The results are set out in *Table I.*

Table I

No. of Experiment	Severity	Length	Duration	Initial Blood-pressure	Final Blood-pressure	Effect Produced
		cm.	hr.	mm.	mm.	
1	Moderate; red; viable	17	20	110	110	Rise of 30 mm., settling to 110 mm. within 2 hr.
2	Very mild; pink; viable	17	24	120	140	Slight rise of 10–20 mm., with extrasystoles
3	Very mild; pink; viable	17	24	110	110	Stable for 2 hr.
4	Very mild; slight congestion	17	22	160	140	Fall of 20 mm. in 2 hr.; marked cardiac effects (*Fig.* 153)
5	Mild; pink; viable	17	22	120	70	Fall of 50 mm. in 2 hr. (*Fig.* 152)
6	Severe; red; viable	17	24	120	60	Fall of 60 mm. in 2 hr.
7	Mild; pink; viable	17	23	130	100	Fall of 30 mm. in 2 hr.
8	Mild; pink	17	24	120	110	Decline of 30 mm. for 2 hr. followed by stabilization at 110 mm.
9	Moderate; red; viable	17	26	110	70	Fall of 40 mm. in 2 hr.
10	Severe; red; just viable	25	22	150	90	Fall of 60 mm. in 2 hr.
11	Mild; pink; viable	20	25	90	50	Fall of 40 mm. in 3 hrs.
12	Very severe; doubtful viability	20	22	90	75	Decline of 15 mm. in 2 hr.
13	Severe; red; just viable	20	20	80	65	Fall of 25 mm. in 3 hr.
14	Moderate; red; viable	20	20	120	90	Fall of 60 mm., later stabilizing at new level of 90 mm. Hg.
15	Mild; pink; viable	20	21	120	90	Fall of 60 mm., stabilizing at 90 mm. at end of 5 hr.
16	Very mild; pink; viable	20	20	140	115	Fall of 25 mm. in 3 hr.
17	Moderate; red; viable	20	21	130	115	Fall of 15 mm. in 4½ hr.
18	Moderate; red; viable	17	22	80	—	Died in 2 hr.
19	Severe; red; viable	17	22	40	—	Died in 45 min.
20	Moderate; red; viable	20	21	90	—	Died in 4½ hr.

Of the 20 cases recorded, 2 showed a mild pressor response, 1 remained completely unaffected by the relief of strangulation, 14 showed reductions in blood-pressure of varying degrees, a typical example being shown in *Fig.* 152.

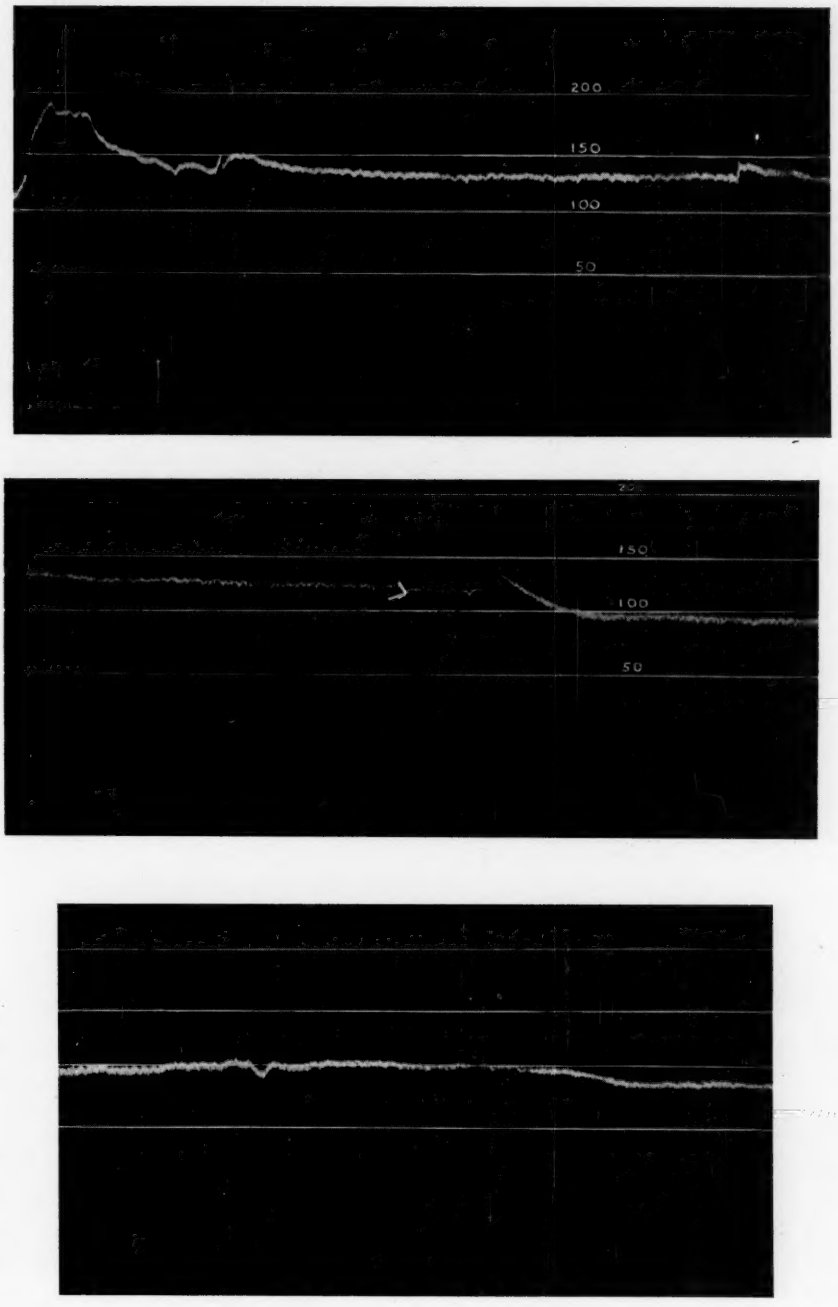

FIG. 152.—Carotid blood-pressure record showing a decline of 50 mm. Hg pressure on relief of a mild viable strangulation of 22 hours' duration.

In one experiment particularly marked cardiac irregularities were observed (*Fig.* 153).

In three cases, or 15 per cent, death occurred following the release of the strangulation, as in the experiment described in a previous communication. It is not possible either from a study of this table or from histological examination of the tissues of the gut wall, to relate the varying effects observed to alterations in the degree of severity of the strangulation. Thus the two cases showing pressor effects,

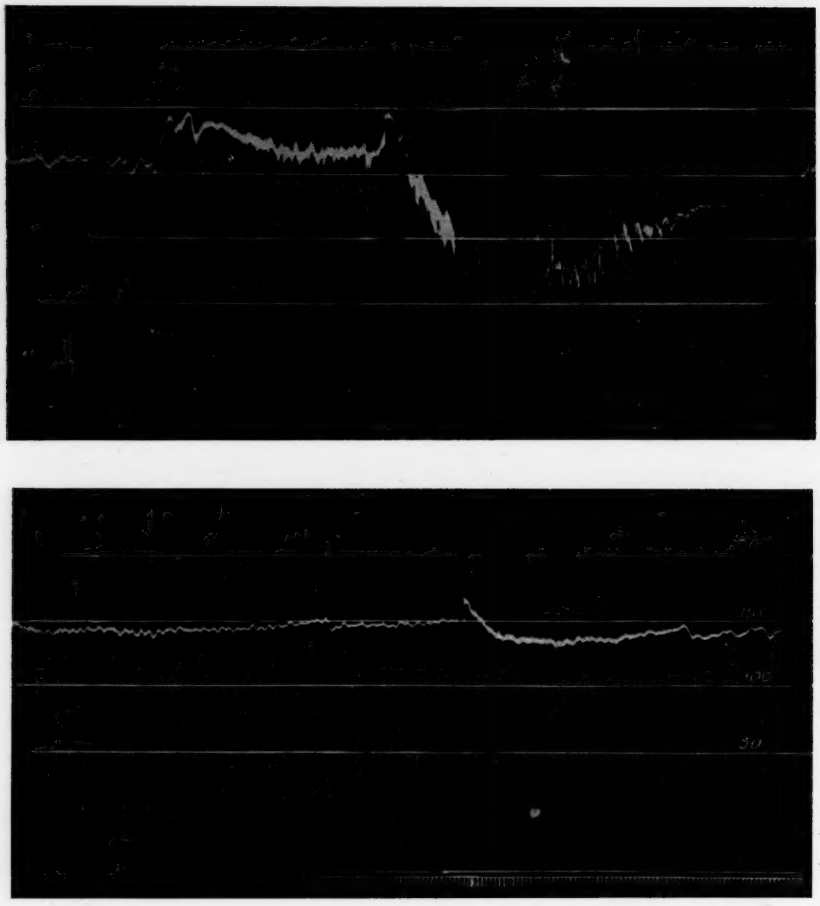

FIG. 153.—Blood-pressure record showing the marked cardiac irregularity and depressor effect produced by the relief of a mild viable strangulation of 22 hours' duration.

macroscopically appeared precisely similar to other viable cases in which a fall of blood-pressure had occurred (cf. *Experiments* 1 and 2 with 9 and 16), whilst two cases on the borderline of viability (*Experiments* 12 and 13) in which marked depressor reactions had been expected, showed falls of small magnitude (15 mm. in 2 hours and 25 mm. in 3 hours) although the general condition of the animals had been affected and the initial blood-pressure was low.

One fact emerges clearly from this table, that death of the animal following relief of the strangulation has only occurred in cases where the initial blood-pressure

has been low and the animal already toxic. Since the survival period of strangulations of this group, as shown previously, is about 48 hours, it would seem that the giving of an anæsthetic and the relief of the strangulation produced this lethal result.

Whilst it is apparent to us that animals suffering from the toxæmia of strangulation tolerate shock and hæmorrhage very poorly, the rapid opening of the previous wound with division of one rubber band and constricting ligatures can be performed within a few minutes, and, in our opinion, is insufficient alone to account for the death of the animals; and, as will be seen elsewhere in the table, animals with similar strangulations and similar blood-pressure have tolerated this procedure without fatal outcome.

In an attempt to analyse whether these results depend upon the release of toxic substances from the mesenteric veins and lymphatics alone, or are modified by the escape of the contents of the loop into a lower segment of the bowel, or entry into the loop of obstructed content from above, in certain experiments the compressing band around the mesentery was divided, leaving the obstructing ligatures around the gut intact, thus keeping the lumen of the strangulated segment isolated. A fall of pressure resulted on relief of the veins and lymphatics of the mesentery by division of the obstructing band, which was not modified by subsequent release of the ligature surrounding the gut lumen.

It appears, therefore, that the results described are due to the release of toxic substances from the veins and lymphatics of the strangulated segment. These toxic substances are only sufficient, however, to produce at the most a 15 per cent mortality following the relief of viable segments of approximately 24 hours' duration in animals whose circulation is already depressed following previous toxic absorption. It is interesting that the persistent decline in blood-pressure, the pressor responses, and the cardiac effects observed in various cases following the relief of strangulation correspond to the three types of reaction obtained from the blood from strangulated segments when tested by intravenous injection in the normal animal.

EXPERIMENTS WITH HUMAN MATERIAL

The recognition of similar depressor reactions in the urine of experimental animals and human patients with known strangulations, led us to extend our experiments to the investigation of the blood and peritoneal fluid obtained from human cases, in order to determine whether these contained substances similar to those demonstrated in animal experiments. In this we have been most fortunate in receiving the collaboration of the various members of the Surgical Staff of St. Bartholomew's Hospital, for whose help in the collection of material at operation our sincere thanks are due. Samples of fluid removed from the peritoneal cavity and hernial sacs in the course of operation, and blood collected from the mesenteric veins of excised non-viable segments of gut, have been tested by intravenous injection in chloralosed cats, and the result determined by continuous blood-pressure records. The record is allowed to continue until the animal's condition has fully stabilized, in order to eliminate the false impression which might otherwise be received in those cases where a marked initial depressor reaction is followed later by a return of the blood-pressure to a somewhat higher level. In no case were citrated solutions employed, as over-citration is a potent source of fallacy in these reactions.

The results of these experiments may perhaps be received with some reserve. The injection of human blood and peritoneal fluids intravenously in the cat has

a medieval flavour which promotes scepticism. Such heterologous experiments must be subjected to strict control to exclude the possibility that the changes in blood-pressure result from the introduction of foreign material, quite apart from the influence of strangulation. We have therefore performed injections of fresh normal human blood, of human hydrocele fluids, and of large quantities of blood-stained serum obtained from non-infected hæmatomas of several days' duration. This latter procedure was adopted since it has been shown that depressor substances are produced in the early stages of disintegration of blood.

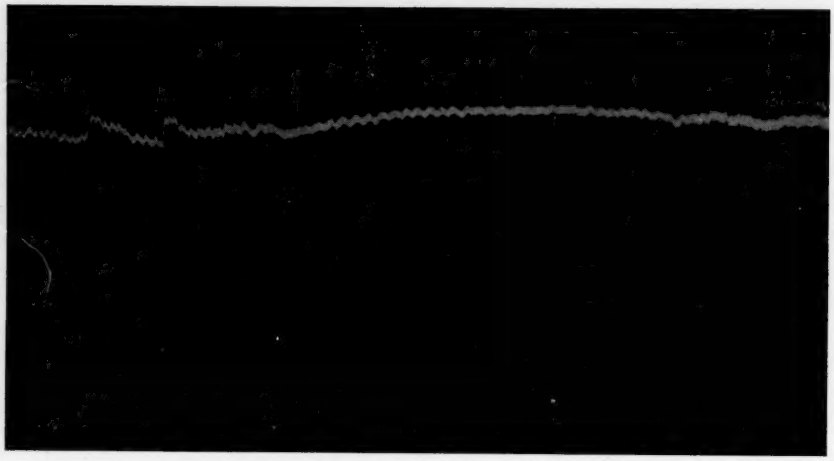

FIG. 154.—Blood-pressure record showing the pressor effect produced in the cat by the injection of 30 c.c. of human blood-stained serum.

The results were as follows. Fresh normal human blood on intravenous injection in certain cases produces a sudden rapid drop in the blood-pressure of the cat, followed by a recovery to the previous level. Prolonged permanent depression of blood-pressure was not, however, observed.

Continuous intravenous infusion of large quantities of human blood-stained serum is purely pressor in reaction (*Fig.* 154.)

A pure pressor reaction is also observed following intravenous injection of hydrocele fluid (*Fig.* 155, *Signal* 1).

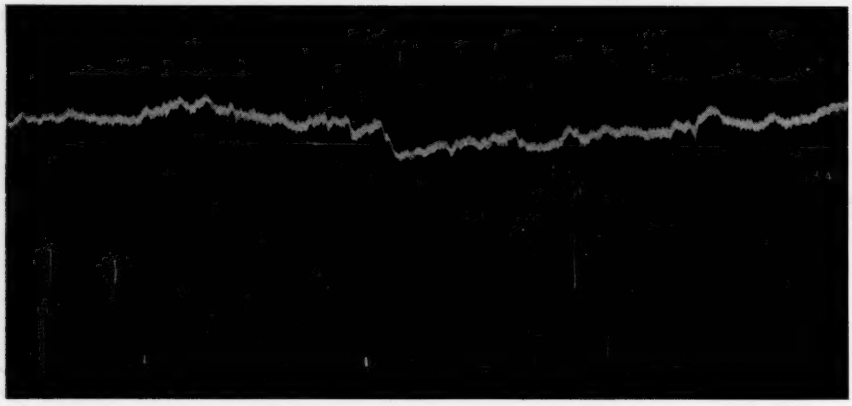

FIG. 155.—Blood-pressure record showing the pressor effect produced in the cat on the injection of 3 c.c. human hydrocele fluid (*Signal* 1) and the depressor effect from injection of 2 c.c. of peritoneal fluid from a viable strangulation of 2 hours' duration (*Signal* 2). (*Experiment* 1, *Table II*).

Table II

No. of Experiment	Approximate Period of Strangulation	Condition of Gut	Appearance of Fluid	Dose	Effect Produced	Stabilization
	hr.			c.c.		
1	2	Pink; viable	Marked blood contamination	2	Fall of 15–20 mm.	To normal in 10 min.
2	3	Deep purple; viable	Faint blood staining	5	Fall of 50 mm.	Immediate recovery of 25 mm., returning to normal in 7 min.
3	5	Pink; viable	Marked blood contamination	12	Pressor	—
4	7½	Red; viable	Faint blood staining	10	Fall of 30 mm.	Permanent lowering; cardiac irregularities
5	8½	Mild congestion	Faint blood staining	3	Gradual decline	At 50 mm. lower after 1 hr.
6	18	Red; viable	Faint blood staining	1·6	Gradual decline	At 20 mm. lower after 1 hr.
7	22	Small intestine distended; viable knuckle in right inguinal hernia	Yellow intraperitoneal fluid	2·5	Gradual fall of 50 mm.	Recovery to permanently lower level of 25 mm. after 1 hr.
8	24	Red; viable	Yellow	3	Fall of 50 mm.	Complete recovery to normal in 3 min.
9	24	Pink; viable	Yellow	4·5	Fall of 60 mm.	To normal in 3 min.
10	18	Gangrenous	Dark	3	Gradual fall of 35–40 mm.	At permanently low level
11	48	Gangrenous	Dark	2	Fall of 50 mm.; progressive decline of 90 mm.	At permanently low level
12	72	Gangrenous	Dark	7	Fall of 50 mm.; progressive decline of 70 mm.	At permanently low level

Peritoneal Fluid.—The results of injection of samples derived from strangulations of varying severity and duration are shown in *Table II.*

The variations in reaction were similar to those obtained in animal experiments. An isolated pressor reaction, examples showing cardiac irregularities, and, in the majority of cases, presistent depressor reactions are seen. A study of the table does not disclose a progressive increase in depressor effect with the *period of*

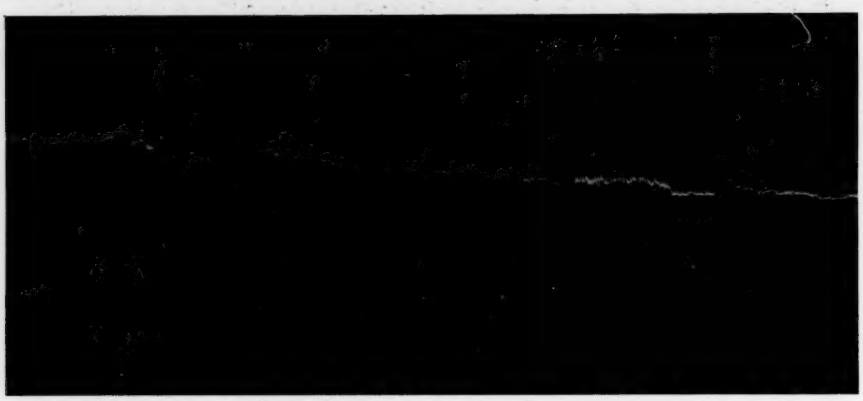

FIG. 156.—Blood-pressure record showing a continuous depression of 50 mm. Hg following the injection of 3 c.c. of peritoneal fluid from a human strangulation of 8½ hours' duration. The gut was only mildly congested. (*Experiment* 5, *Table II.*)

strangulation alone. The marked effects obtained in all cases where the viability of the gut is impaired does, however, show an increase in toxicity parallel to the *severity of the strangulation* as demonstrated in animal experiments. The earliest case of 2 hours' duration shows a very mild depressor reaction (*Fig.* 155, *Signal* 2);

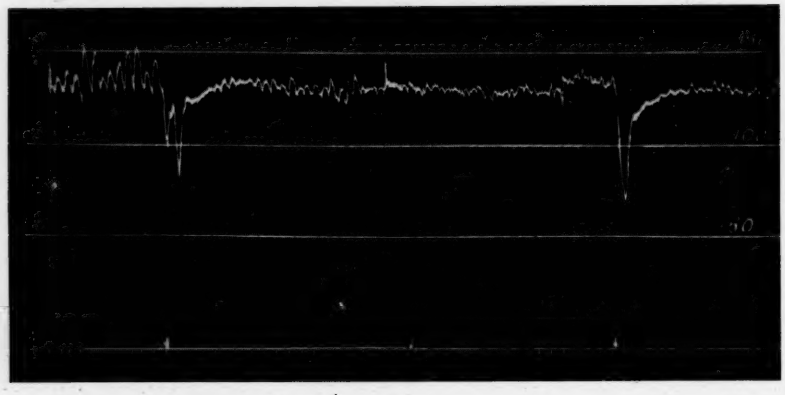

FIG. 157.—Blood-pressure record showing the sharp depressor effects with rapid recovery on injection of 3 c.c. and 2 c.c. of peritoneal fluid from a human strangulation of 24 hours' duration. (*Experiment* 8, *Table II.*)

at 5 hours a sample of peritoneal fluid, heavily contaminated with blood, was purely pressor (a further useful control); 3 c.c. of a sample derived from a strangulation of 8½ hours' duration produced a continuous depression of 50 mm. Hg in blood-pressure (*Fig.* 156); whereas two samples of 24-hour fluids show a sharp depression with recovery to almost the original level on injection of 3 c.c. and 2 c.c. (*Fig.* 157, *Signals* 1 and 3).

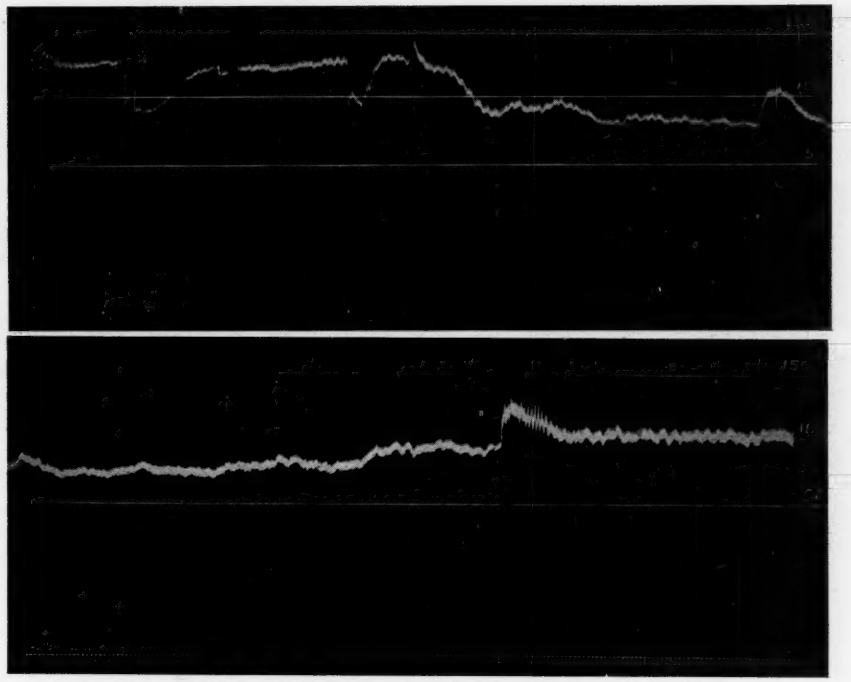

FIG. 158.—Blood-pressure record showing :—
Signal 1.—The sharp depressor effect with complete recovery following the injection of 5 c.c. of peritoneal fluid from a human strangulation of 3 hours' duration. The gut was severely congested. (*Experiment* 2, *Table II.*)
Signal 2.—The prolonged depressor effect and final reduction of 25 mm. Hg. from the injection of 2·5 c.c. of the fluid in the general peritoneal cavity in a strangulated inguinal hernia of 22 hours' duration. (*Experiment* 7, *Table II.*)

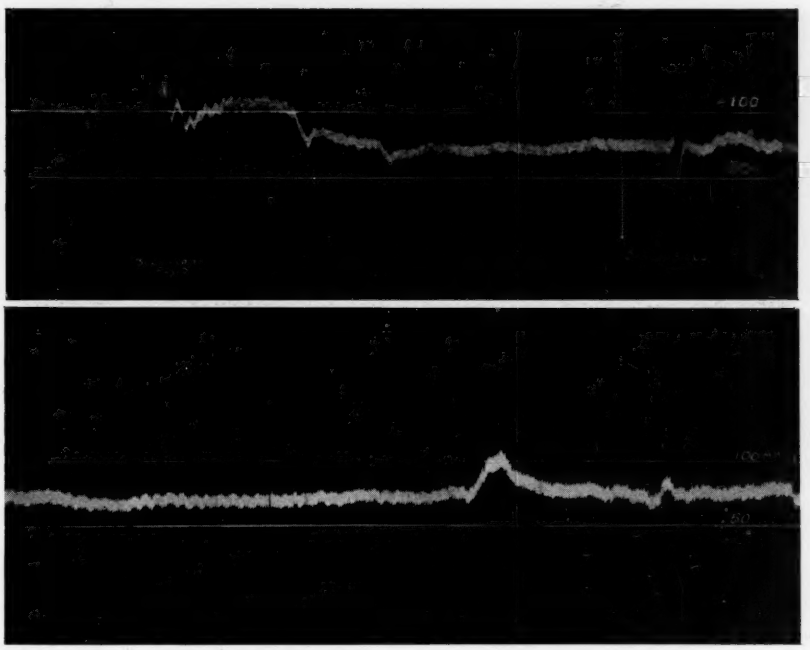

FIG. 159.—Blood-pressure record showing :—
Signal 1.—The progressive depression of 40 mm. Hg following the injection of 3 c.c. peritoneal fluid from an 18-hour human strangulation in which the gut was non-viable. (*Experiment* 10, *Table II.*)
Signal 2.—The rapid depressor effect with complete recovery on the injection of 0·5 c.c. blood from the same case.

The reaction in *Experiment* 7 is of interest, for this fluid was obtained from the general peritoneal cavity in a case where laparotomy was performed for a small unrecognized hernia of 22 hours' duration; although the viable gut was lying shut off within the hernial sac, the yellow fluid from the peritoneal cavity produced a depression of 50 mm. Hg in blood-pressure on injection of 2·5 c.c. This stabilized later to a final reduction of 25 mm. one hour after injection (*Fig.* 158). It is possible that this effect may be due to the distension of the upper segment of the intestine,

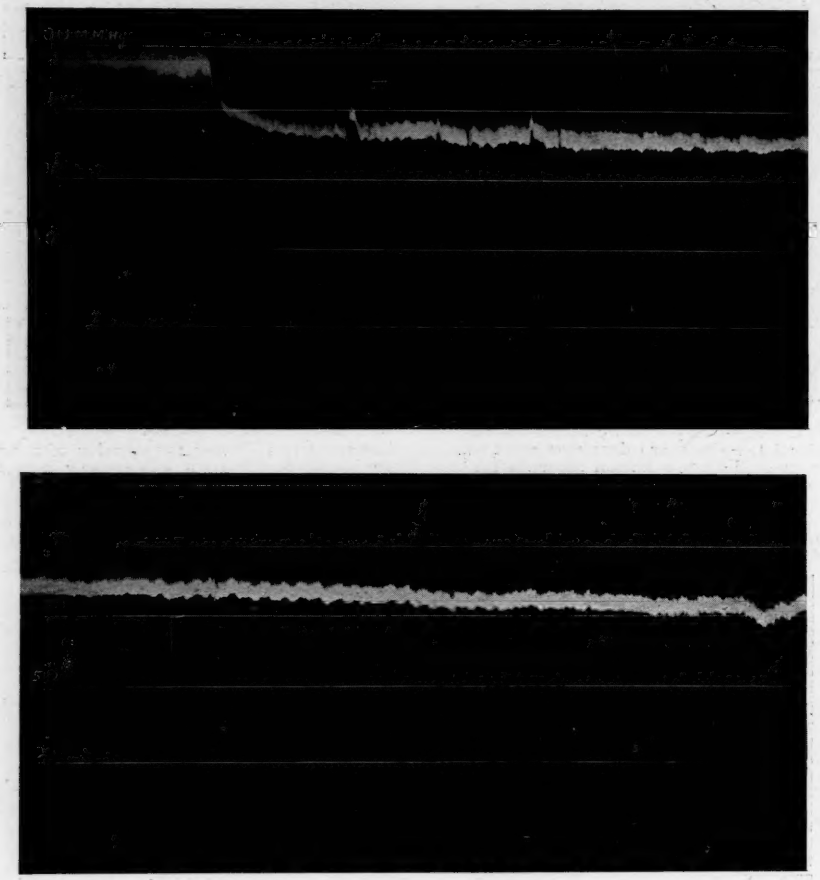

FIG. 160.—Blood-pressure record showing:—
Signal 1.—Fall of 50 mm. Hg pressure and progressive decline of 80 mm. from the injection of 2 c.c. of peritoneal fluid from a human strangulation of 48 hours' duration in which the gut was non-viable. (*Experiment* 11, *Table II.*)

for we have observed similar depressor reactions in the peritoneal fluid in late cases of simple obstruction without strangulation, when distension of the gut had become marked.

In all cases where the gut was non-viable marked depressor effects were observed irrespective of the period of strangulation. In *Fig.* 159, *Signal* 1, is seen the continuous reduction in pressure from the original level of 110 to 70 mm. Hg, maintained for four hours following the injection of 3 c.c. of peritoneal fluid obtained from an 18-hour non-viable femoral hernia.

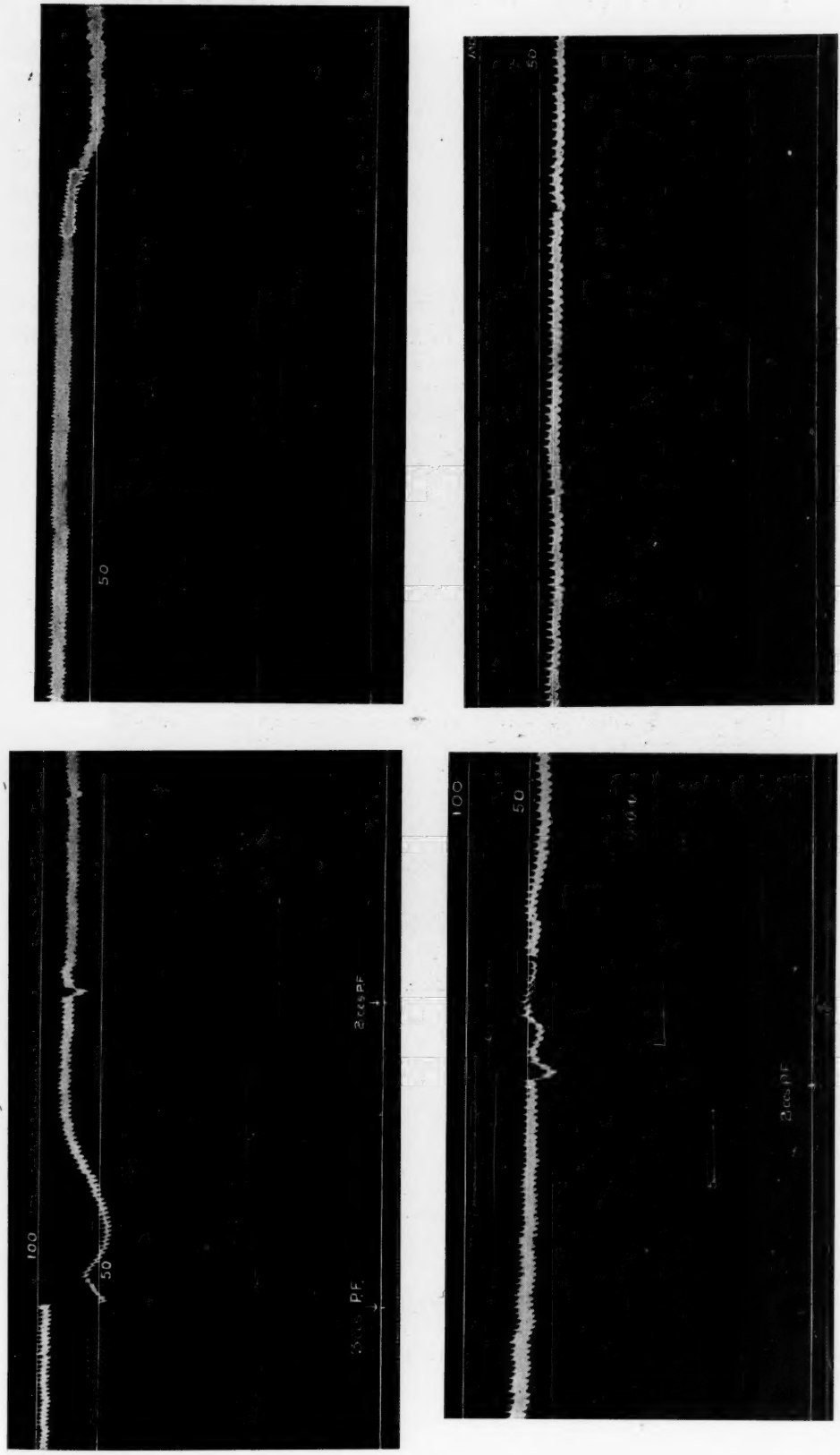

FIG. 161.—Blood-pressure record showing the fall of 50 mm. and progressive decline of 70 mm. Hg following the total injection of 7 c.c. of peritoneal fluid from a human strangulation of 72 hours' duration, in which the gut was non-viable. (*Experiment* 12, *Table II.*)

Fig. 160 shows the marked permanent lowering of 80 mm. Hg maintained for two hours following the injection of 2 c.c. of peritoneal fluid from a 48-hour non-viable Richter's hernia of the cæcum. In both these cases the patients recovered following resection.

Fig. 161 shows the progressive decline in blood-pressure over four hours from 100 to 30 mm. produced by the injections of a total of 7 c.c. of peritoneal fluid obtained from an internal strangulation of the terminal ileum of 72 hours' duration. In this case the patient died 5 hours after relief of the strangulation and invagination of a small non-viable area.

Whether these more marked effects are due to the appearance of bacterial toxins, or are the result of the presence of greater concentrations of the depressor

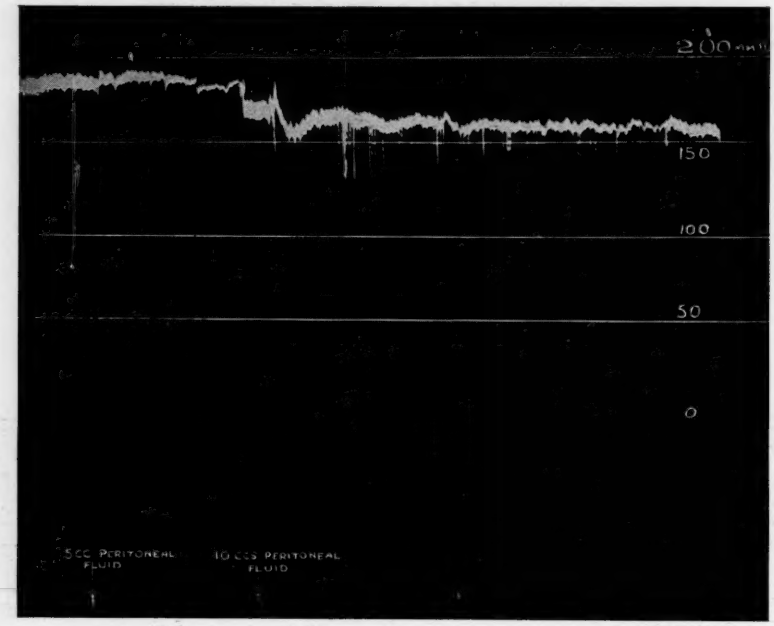

FIG. 162.—Blood-pressure record showing:—
Signal 1.—The absence of effect on injection of 5 c.c. of peritoneal fluid from a human strangulation of 7½ hours' duration.
Signal 2.—The fall of 30 mm. Hg pressure and cardiac irregularities on injection of 10 c.c. of peritoneal fluid from the same case. (*Experiment* 4, *Table II.*)

substances present in the early stages, cannot be settled on the basis of these crude experiments. That larger doses do produce a persistent lowering in pressure, whereas small doses are without effect or are followed by a complete recovery, is shown in *Fig.* 162. In this experiment the injection of 5 c.c. of fluid obtained from a viable strangulation of 7½ hours' duration produces little effect; the injection of 10 c.c., however, causes a permanent lowering of 30 mm., with numerous cardiac irregularities.

Gut Blood.—The blood obtained from the mesenteric veins of non-viable segments after excision was augmented in certain cases with normal saline washings. In all the four cases tested a depressor reaction was obtained similar to those observed in animal experiments.

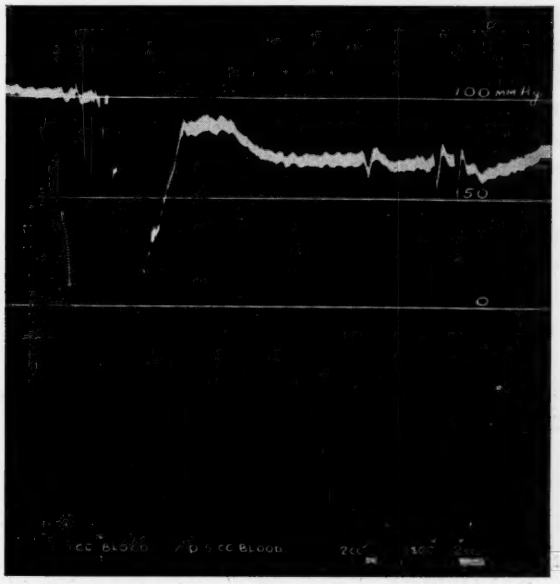

FIG. 163.—Blood-pressure record showing the depressor effects produced by the injection of *Signal* 1, 1 c.c., *Signal* 2, 0·5 c.c., of blood from a 12-hour non-viable volvulus of the jejunum. *Signals* 3, 4, and 5 show the minor effects produced on the injection of samples of blood diluted 1–10 with saline.

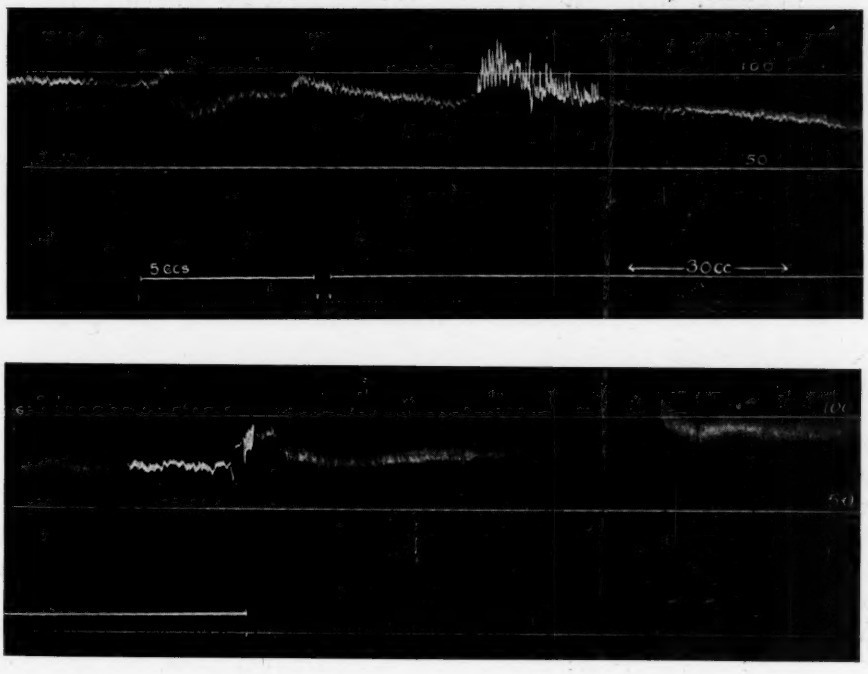

FIG. 164.—Blood-pressure record showing the continuous depressor effect produced by the intravenous injection of 35 c.c. of 1–10 saline and blood (= 3·5 c.c. of blood) from a 48-hour non-viable human strangulation.

In *Fig.* 159, *Signal* 2, a sharp depression with immediate recovery to the previous level occurs following the injection of 0·5 c.c. of blood (5 c.c. 1–10 saline) from a non-viable femoral hernia of 18 hours' duration.

Fig. 163 shows a marked depression with permanent reduction in pressure following the injection of 1 c.c. and 0·5 c.c. of whole blood from a non-viable volvulus of the small intestine of 12 hours' duration. Cardiac irregularities during the recovery phase, and minor depressions from later injection of diluted samples, are also seen. This patient recovered following resection.

Fig. 164 shows the maintained depression resulting from continuous infusion of 35 c.c. of 1–10 saline and blood (= 3·5 c.c. of blood) derived from the veins of a 48-hour non-viable femoral hernia, in which case the patient died following resection (cf. *Fig.* 154). It will be seen that following this injection the blood-pressure stabilizes at the previous normal level only, whereas 35 c.c. infusion should, in the absence of depressor substances, produce a rise in blood-pressure.

DISCUSSION

It has been shown that in animals relief of viable segments of strangulated intestine can cause the death of the experimental animal from the re-entry into the circulation of toxic substances previously dammed back in the veins of the affected loop. This result is seen in 15 per cent of cases, and occurs only in those animals whose general condition is seriously impaired prior to release of the strangulation.

For a similar result to be possible in the *human* it is necessary to establish that toxic substances are present in the veins of the strangulated loop. Our results show that in human strangulations depressor substances are present in the venous blood and peritoneal fluid which show similar reactions to those demonstrated in previous animal experiments. To affirm from these results that resection is to be preferred to simple relief of the strangulation in all cases is, however, absurd. The total amount of depressor substances present in the veins and lymphatics is not known, and, as has been shown, is well tolerated by animals which are in good condition prior to release of the strangulation. If one may argue directly from animal experiments to clinical practice, it appears that, in patients whose condition is good, resection is only indicated by the non-viability of any portion of the gut. In patients in poor condition as the result of toxic absorption prior to operation, it may well be that a proportion of these cases will succumb as the result of continued absorption following release of the strangulation. To diminish this post-operative toxæmia, since the peritoneal fluid contains noxious substances, as much as possible should be removed without prolonging the operation and handling unduly.

Whether exteriorization or rapid resection of *viable* gut is to be preferred to simple relief of the strangulation in a toxic patient can only be answered if a precise determination of the toxic content of the gut blood in viable cases can be secured and proves to be large in amount. Material for such investigations can, however, seldom be obtained.

A study of the statistical tables does not really illustrate this point. It is known that the mortality-rate rises rapidly with the period of strangulation on account of increasing toxæmia. Typical figures are those of Christopher and Jennings[7] and McIver,[8] shown in *Table III.*

The high mortality-rate for resection (e.g., McIver 73 per cent; Miller[9] 73 per cent) compares most unfavourably with the standard figures for release of

Table III

Duration of Symptoms before Operation	McIver: Mortality of Internal Strangulation	Christopher and Jennings: Mortality of Volvulus
	per cent	per cent
Less than 24 hours ..	17	—
24–48 hours ..	35	33·3
Over 48 hours ..	60	80

strangulation alone (e.g., McIver 68 cases, 19 per cent; Miller 86 cases, 40 per cent); but it is obvious that resection will be performed, in the majority of cases, in the later stages in the presence of grave toxæmia, whereas relief of the strangulation is frequently performed in the early stages where the patient's general condition is good. Such figures do not therefore indicate the relative value of the two operative procedures in the toxic patients. Where the viability of any portion of the gut is borderline or doubtful, the possibility of toxic absorption is an additional factor indicating resection or exteriorization in such cases rather than return of the loop or invagination. The high mortality which has been demonstrated by some observers for the operation of invagination (e.g., Miller 12 cases, 97·5 per cent) is doubtless accounted for by the fact that this conservative measure has been employed in patients who were gravely toxic at the time of operation. It compares unfavourably, however, with the general figure of 73 per cent for resection, and may be due in part to continued absorption from the invaginated segment. In cases where exteriorization is performed avoidance of distension in the upper segment is of importance, since it appears that such distension results in the appearance of further depressor substances in the peritoneal fluid.

Even if it should appear in the future that modification of the accepted principles of operation in the direction of more frequent excision or exteriorization is indicated, such a measure would only produce a moderate reduction in the mortality-rate, the essential feature of which is the degree of toxic absorption which occurs prior to operation. To diminish this by early diagnosis and combat the effects by suitable treatment is of the greatest importance. Since such treatment can only have a rational basis when the nature of the toxic substances and their mode of action and elimination have been fully established, every effort must be made to elucidate these points. In this connection the examination of human material presents a fruitful field.

SUMMARY

1. Depressor substances are present in the peritoneal fluid and gut blood in human cases of intestinal strangulation.

2. In experimentally produced viable strangulations release of the strangulation causes circulatory collapse and death in 15 per cent of cases. This result is only seen if the general condition is impaired prior to operation.

3. The advisability in a toxic patient of (*a*) the removal of the peritoneal exudate, (*b*) the more frequent excision or exteriorization rather than release or invagination of gut which is severely congested and of borderline viability, is discussed.

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SHORT NOTES OF RARE OR OBSCURE CASES

BILATERAL FRACTURE OF THE HUMERUS DUE TO ELECTRIC SHOCK

By J. E. SEMPLE, London

In the British Journal of Surgery of July, 1936, Mr. H. Jackson Burrows reported three cases of fracture of the humerus due to electric shock, and reviewed the literature on this subject.

The following is the report of a patient who suffered a bilateral fracture of the humerus as a result of such an electric shock.

Fig. 165.—Radiograph of the right shoulder soon after the accident, showing a fracture of the upper end of the humerus with some comminution. Probable injury to the posterior and lower part of the glenoid.

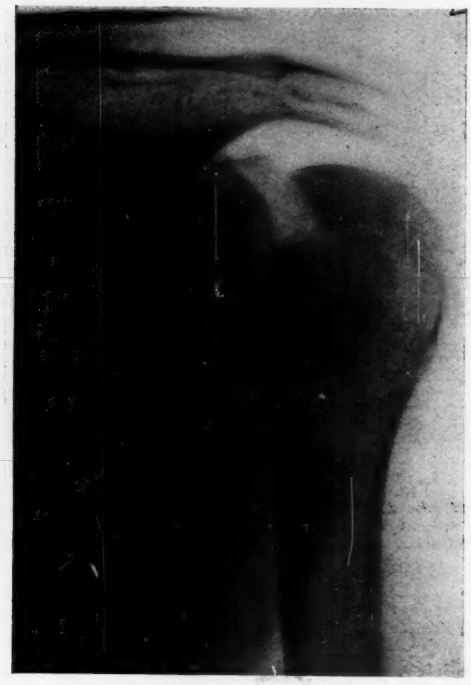

Fig. 166.—Radiograph of the left shoulder soon after the accident, showing a comminuted fracture of the upper end of the humerus with displacement of fragments. Injury to the upper part of the glenoid.

On Dec. 31, 1935, the patient, aged 58 years, an electrician, was cutting an old electric cable which he believed had been disconnected from the main. Owing to the situation of this cable he had to support himself by holding an iron pillar with his left hand while he cut through the cable with pliers. As he did so he

received a shock from the cable, which was afterwards found to be carrying an alternating current of 50 cycles of 240 volts. He was doubled up by the shock and was unable to release his grip until the current was switched off about two to three minutes later. He was not rendered unconscious, but he was unable to straighten himself from the extreme position of flexion for ten to twenty minutes.

On admission to hospital he was suffering from a moderate degree of shock. He complained of some pain in the upper part of both arms, " as though the muscles were stretched ".

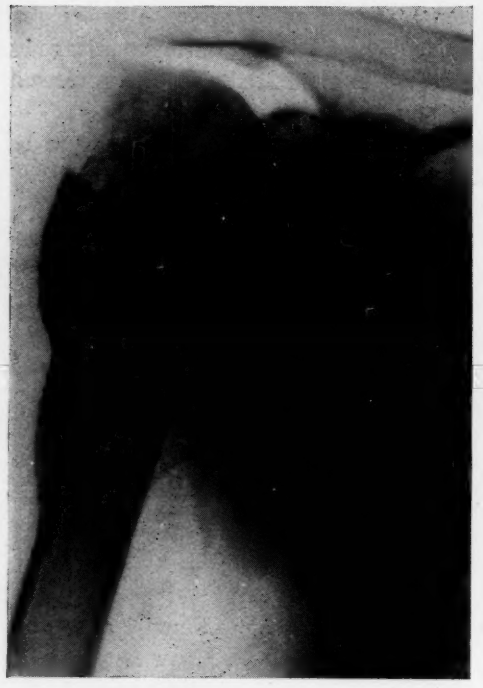

FIG. 167.—Radiograph of the right shoulder six months after the accident. Marked excess of callus between shaft of humerus and upper fragment of humerus and glenoid.

FIG. 168.—Radiograph of the left shoulder six months after the accident, showing excess of calcified callus between the upper fragment of the humerus and the glenoid, obliterating the joint cavity. Probably a false joint between the shaft and the large upper fragment of the humerus.

ON EXAMINATION.—The patient was seen to be of short but powerful build with a well-developed musculature. There was no evidence of burns. The muscles of the shoulders and arms were soft and relaxed. Active and passive movements of the shoulder-joints were painful, but crepitus was not elicited.

X rays showed bilateral fracture of the neck of both humerus bones (*Figs.* 165, 166).

TREATMENT.—This consisted of abduction of the arms, followed by early movement.

The patient ran an irregular temperature, rising to 101° at nights, for four days, after which it returned to normal.

ON EXAMINATION SIX MONTHS LATER.—The patient complained of little pain in the shoulders except at the limits of range of movement. The right shoulder could be abducted to 40° with the scapula fixed, and to 90° with the aid of scapula movement. Flexion is reduced to 20°, but 90° of flexion can be obtained when the scapula is free. Crepitation in the joints is marked. The left shoulder allows 45° of abduction with a fixed scapula, and 100° when the scapula is free. A similar degree of flexion is obtainable. Rotation of both arms at the shoulder is about 10°. Muscular power is good in both arms and forearms.

An X-ray photograph of both shoulders shows excessive formation of callus (*Figs.* 167, 168).

Much of the recovery is due to the determination of the patient, who does his utmost to overcome and diminish his disability.

Commentary.—

1. There is marked similarity between the radiographs shown in Mr. Burrows's article and those of the present patient.

2. In this case the patient did not fall as a result of the shock; the fracture must therefore be largely due to the excessive contraction of the shoulder muscles, the bone being weakened, as Jellinek suggests, by the passage of the current.

3. The characteristic feature of the skiagrams is the excessive comminution of the upper end of both humerus bones—almost as if the head of each bone had 'burst'. *Fig.* 166 shows that a portion of the articular surface of the humerus is fractured and displaced, while the upper portion of the glenoid cavity is reported as being injured. It is difficult to account for such fractures purely as the result of muscle-pull, even on weakened bone. Under such circumstances, in spite of adverse evidence, it seems a pity to abandon entirely such theories as: (*a*) Heat formation at a point of high resistance (such as a large joint), as the heating of a joint in such a manner is made use of in diathermy treatment, and may be destructive if the current is excessive; (*b*) That the joint may play the part of a condenser which if over-charged might cause damage to the joint tissues. Even though these mechanisms may not be wholly responsible for the weakening of the bone, it would be difficult to prove their entire absence.

4. There was little evidence of any inflammatory reaction or sequestrum formation due to the necrosis of the bones, as reported in Palugyay's case. Nor do the present radiographs suggest a Sudeck's atrophy of the bone (painful post-traumatic osteoporosis); in fact the callus formation on the right side tends to be excessive.

I should like to express my gratitude to Mr. Woodd-Walker for allowing me to publish this case, and to Dr. Post for his report on the X-ray photographs.

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CALCULOUS EXFOLIATIVE CYSTITIS

By SIR W. I. DE COURCY WHEELER, London

The term calculous exfoliative cystitis is used in this communication to express as far as possible the outstanding features of a very unusual case. Exfoliative cystitis was not present when the patient was first admitted to hospital for the removal of calculi from the bladder. The condition developed to a marked degree some weeks after operation, but at post-mortem examination changes in the bladder of a completely different nature were evident.

History.—The history of the case may be briefly summarized as follows. The patient was a married woman, aged 44, with no children. In November, 1935, she sought advice at All Saints Hospital for frequency of micturition and occasional hæmaturia. Seven years ago a stone had been removed from the bladder by suprapubic operation, and a year later a second stone was crushed (details could not be obtained).

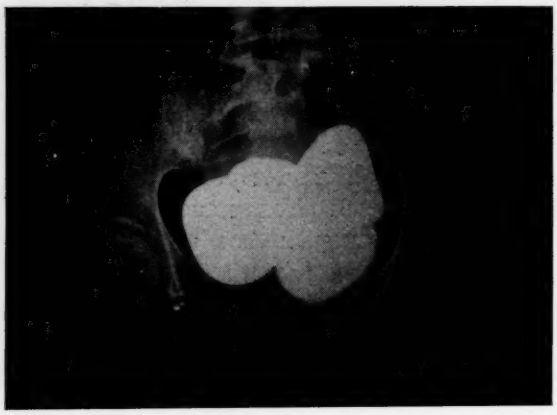

Fig. 169.—Radiograph of stones in the bladder. The stones could be palpated with ease.

On Examination.—On routine examination nothing abnormal was found, until palpation of the lower abdomen revealed the presence of large calculi. During palpation, if the patient's position was changed, the stones could be felt grating one upon the other. X-ray photographs demonstrated the presence of four large calculi (*Fig.* 169).

The urine was alkaline. It was loaded with Gram-positive cocci and large numbers of various bacteria. There were no renal casts. The blood-urea was within the range of normal, and estimations of the urea concentration and urea nitrogen gave low but not unsatisfactory results. Radiographs after intravenous injection of abrodil gave further evidence of healthy renal function. The kidneys were seen to be normal in size, shape, and position.

Removal of Vesical Calculi.—Four large stones were removed by suprapubic cystotomy. The interior of the bladder was visualized and explored; there was no evidence of gross pathological changes in the bladder wall.

The opening in the bladder was closed without drainage. The immediate after-treatment consisted of bladder irrigation and the internal administration of urinary acidulants and disinfectants. The patient was discharged from hospital in four weeks.

The symptoms from which she had suffered, with short intervals of relief, for over seven years, persisted after removal of the stones, and the urine remained loaded with pus. Cystoscopic examinations now revealed well-marked exfoliative

cystitis. The appearances were almost exactly those described by Hinman. Plaques of dirty grey colour, composed of necrosed membrane, fibrin, leucocytes, bacteria, and debris occupied each visual field. They were elevated, soft, and adherent in places, or hung like curtains or stalactites from the bladder wall. At times, says Hinman, these membranes loosen and become infiltrated with lime salts or are detached and pass out with the urine. Incrustation was never a feature of the case, although occasionally there was some evidence of infiltration with lime salts, when the patient neglected regular treatment. (The *Bacillus proteus ammoniæ* was not found.) It was never possible to see the ureteric orifices during the many cystoscopic examinations.

COMPOSITION OF THE STONES.—The four stones (*Fig.* 170) weighed together 16¼ oz., or slightly over 1 lb. They were almost identical in size and shape. They were faceted and smooth on the surface. On section there was a nucleus of uric acid, mixed with a trace of calcium phosphate, surrounded by a laminated deposit of magnesium and calcium phosphate, calcium carbonate, organic matter, and water. It is interesting to remember that stones in women are rare, and when they do form it is usually in the presence of some foreign body. Infection alone is not enough. (Joly mentions that there are four stones in the collection at St. Peter's Hospital each weighing over 4 oz. They appear to be identical in weight with those now described. He mentions that the largest vesical calculus on record weighs 5 lb.)

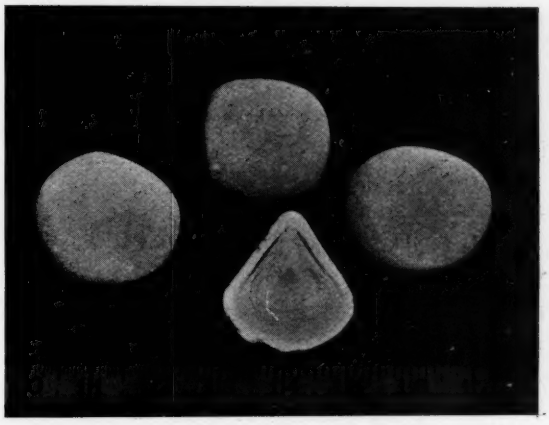

FIG. 170.—Photograph of stones after removal. Total weight, 16¼ oz. The lowest stone is shown in section.

SUBSEQUENT TREATMENT.—From the beginning to the end the treatment of this case was unsatisfactory and disappointing. Almost every well-known urinary antiseptic and acidulant was employed internally and locally. When one failed another was substituted without effect. Preparations such as mandelic acid and the strong nitro-hydrochloric acid gave no better results than the more orthodox prescriptions from the hospital formulary. Halibut oil was administered in the hope of supplying some vitamin deficiency. The bladder was irrigated with solutions of acetic acid, hydrochloric acid, and phosphoric acid, at varying intervals, in an attempt to alter the reaction of the urine. On several occasions cod-liver oil was instilled into the bladder after irrigation.

After two months' treatment along these lines in the out-patient department, the patient was re-admitted into hospital. Continuous bladder irrigation was tried. There were periods of some improvement, always followed by severe relapse. It now became obvious that more radical treatment was indicated. Eight months had elapsed since the removal of the stones.

Suprapubic drainage, transplantation of the ureters into the colon, or cutaneous ureterostomy appeared to be the three alternatives. Suprapubic drainage had failed seven years previously. It was felt that any improvement from this operation

in the condition of the bladder might be only transient. If the ureters were found healthy and undilated, transplantation into the colon was the operation of choice; if the condition of the ureters was doubtful, cutaneous implantation was recognized as the safest procedure.

On July 7, 1936, the right ureter was transplanted into the pelvic colon by the Mayo method. The ureter appeared normal in every respect. (I have had the privilege of seeing Dr. Charles Mayo and his associates perform this operation, and I have had complete satisfaction from the procedure over a number of years. It appears to be a more simple and certain procedure than many of the more modern modifications.) At the end of a month the rectum had gained good control. About 30 oz. were passed by this route in twenty-four hours. The bladder symptoms became more aggravated, the urine was thick with pus, the frequency was intense, and the patient's general condition was deteriorating from want of rest.

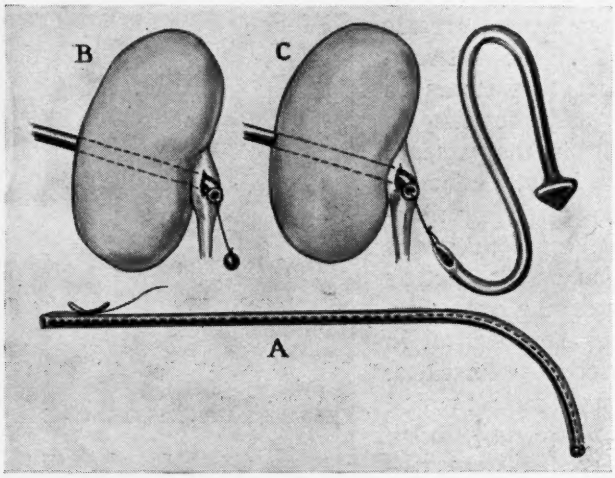

FIG. 171.—A, A modified metal catheter with a steel ball fixed in the terminal eye by means of a thread passed through the lumen; B, The renal pelvis has been incised—the ball, after acting as a guide, is released; C, The ball has been cut off and the thread attached to a winged catheter. (*Reproduced by kind permission of the 'Lancet'.*)

Before transplanting the left ureter, it was thought advisable to perform a temporary nephrostomy on this side. It appeared to us that the operation was a simple one, that it would lessen the risk of the subsequent transplantation, and that in the interval the patient would be free of bladder symptoms and that her general condition would improve. Approximately one month after the transplantation of the right ureter, therefore, the left kidney was exposed in the usual manner. The kidney was mobile and appeared healthy in every respect. The tube was quickly introduced into the pelvis with the aid of a metal catheter originally designed for the repair of a ruptured urethra. *Fig.* 171 indicates the steps of the operation, which resembles the Cabot method. Urine drained freely through the nephrostomy tube. It was acid and sterile.

With the complete diversion of the urine from the bladder the patient's condition became most satisfactory. She was free of pain and discomfort for the first time for several years; 38 oz. of urine were excreted through the tube and 34 oz. per rectum in twenty-four hours.

Our optimistic hopes were short lived. On the tenth day following the nephrostomy, anxieties were aroused by blockage of the tube, a rise of temperature, and some slight hæmorrhage. The tube was changed and for some days there was no further trouble. Later there was a rigor, a further rise of temperature, and more severe bleeding. Recovery followed blood transfusions. Finally the patient died of secondary hæmorrhage one month after operation.

FIG. 172.—Showing the right ureteric opening into the sigmoid flexure of the colon, two months after transplantation. The ureter appeared normal, but contained some coli bacilli and enterococci.

I have not had previous experience of trouble following temporary nephrostomy. Cabot mentions the possibility of bleeding and fulminating infections when the conditions are favourable to sepsis.

POST-MORTEM EXAMINATION.—The right ureter opened into the colon in valvular fashion. The orifice was healthy (*Fig.* 172). (This was the first post-mortem specimen of transplanted ureter I have seen. It encouraged the belief that the operation as originally described may be recommended with confidence.) The ureter was not dilated, but contained in its lumen a few coli bacilli and enterococci. The ureteric stump near the bladder was soundly healed. The right kidney was

normal. The left ureter and kidney also appeared normal, but at the site of the nephrostomy opening into the pelvis there was a small ulcer and an erosion into a small blood-vessel.

The bladder was neither contracted nor enlarged. The mucous lining showed patches of leucoplakia, and considerable areas of subepithelial blue pigmentation (*Fig.* 173). This blue pigmentation did not appear to be a post-mortem phenomenon.

FIG. 173.—Post-mortem appearances in the bladder. There were patches of leucoplakia, and wide areas of subepithelial blue pigmentation. The ureteric orifices were normal. The stump of the right ureter had healed well. No urine had passed through the bladder for one month.

Conclusions and Summary.—

1. Vesical calculi in women are rare. Usually they form round foreign bodies. The ætiology of the present case is obscure.

2. The kidneys and ureters were healthy in every respect. After eight years of calculous cystitis this is a very uncommon finding.

3. The case recorded is also exceptional inasmuch as the bladder stones could be easily palpated.

4. The changes found in the mucous lining of the bladder are noteworthy.

Dr. Haler, pathologist to the hospital, kindly investigated the post-mortem specimens and gave a report of which the above is an abstract. I am indebted to Mr. J. Harrison, F.R.C.S., my house surgeon, for much assistance in the investigation and treatment of the case. Mr. Shiells has conveyed accurately in his coloured illustrations the post-mortem appearances of the bladder and ureters shortly after death.

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WHEELER, SIR W. I. DE C., *Brit. Jour. Urol.*, 1929, June.

CYST OF THE SUPERIOR MEDIASTINUM

By R. RUTHERFORD, Longtown, Cumberland

History.—Female, 52 years, married, nulliparous. No history of illness until she was 42 years old, when she felt she was going to choke, so much so that she became cyanosed occasionally and had to stop what she was doing. The attacks were particularly aggravated on going up a slope or climbing stairs; and if she took a drink of water to get relief, she found that her neck had to be massaged to force the fluid past the obstruction.

During the past six months she felt a lump above her left collar-bone; she felt the cold more in her left hand than in her right and had noticed that on occasions her left hand was slightly cyanosed. Latterly she had developed palpitations and had felt collapsed.

Clinical Examination.—Stout female. Both supraclavicular fossæ looked equal, and there was no fullness of the neck in the position of the thyroid gland. On palpating the left supraclavicular fossa there was a fullness not present on the opposite side. The radial pulses were equal. The pupils were equal. The vocal cords were normal.

Operation.—Under inhalation anæsthesia a collar incision was made as for thyroidectomy. The thyroid gland was of normal size. On palpating the supraclavicular fossa on the left side an elastic swelling was felt, its upper pole being 1½ to 2 in. below the lower border of the left lobe of the thyroid gland and having no connection with it. The swelling was enucleated with ease intact, and appeared to have no vascular attachments. Its size was that of a duck's egg (*Fig.* 174), its walls were extremely thin, and its contents clear fluid.

Fig. 174.—Mediastinal cyst after removal. (*Natural size.*)

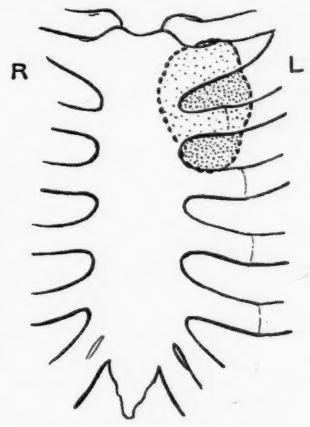

Fig. 175.—Diagram showing position of cyst in mediastinum.

Its anatomical relations at operation (*Fig.* 175) were as follows :—
Upper limit : Inferior surface of left clavicle.
Lower limit : Upper border of 3rd costal cartilage.
Medially : Just internal to the lateral border of the sternum.
Laterally : Upper lobe of left lung.
Anteriorly : Chest wall above and lung tissue below.
Posteriorly : Arch of aorta below and lung above.

The specimen was sent intact to the Curator of the Museum of the Royal College of Surgeons and no microscopic report is available.

The patient made a good recovery and was relieved of her symptoms.

My thanks are due to Dr. Douglas Robertson, Thornton-le-Dale, Yorks, by whom the case was referred.

REVIEWS AND NOTICES OF BOOKS

Traité de Chirurgie orthopédique. Published under the direction of Professors L. OMBRÉDANNE and P. MATHIEU; Editorial Secretaries, M. LANGE, G. HUC, and PADOVANI. In 5 volumes. Large royal 8vo. Vol. I. Physiology, Pathology, and General Treatment. Pp. 902, with 433 illustrations. 1937. Paris: Masson et Cie. Paper covers, Fr. 270; bound, Fr. 300.

THIS magnificent work on orthopædic surgery represents the united efforts of sixty-six French surgeons, and is printed and published in the best style of the well-known publishers. It may be taken, therefore, as an up-to-date and authoritative exposition of the views of the French orthopædic school, and will be an invaluable work of reference.

Volume I deals with the general problems of physiology, pathology, and treatment. In it are described congenital deformities of the limbs, the diseases of bones and joints, and some operative procedures, e.g., osteotomy, osteosynthesis, and arthrodesis, and the affections of muscles, tendons, and fasciæ.

Professors Leriche and Policard deal with the problems of the physiology and pathology of ossification. After describing the histology of growth and repair, they discuss the abnormal processes of ossification and then the problems of bone-grafting. It is held that the transplanted bone dies as a living entity and later becomes permeated with ingrowing bone cells and vessels from the host. Therefore they give qualified approval of the use of prepared dead bone, "os novum", but they consider that fresh autogenous grafts give a quicker and more certain success.

Mathieu has written the chapter on pseudo-arthrosis and has given a well-illustrated account of the technique of various methods, especially the sliding, inlay, medullary, and osteo-periosteal varieties. We think that the massive graft might well have been figured and included.

Osteomyelitis is dealt with by Leveuf. He gives a guarded approval of the waiting policy for intervention in acute cases, and then advises simple incision with only one or two drill holes into the medulla. In selected cases he is in favour of diaphysectomy, but we think that a word of warning might have been uttered about the fear of the bone failing to regenerate. In the treatment of chronic osteomyelitis chief attention is confined to the ablation of diseased bone and to the filling up of the cavity left by skin or muscle flaps. The figure (p. 211) showing skin flaps screwed down to the underlying bone cavity rather shocks our surgical instincts, but if the result is as beautiful as shown by the drawing, then our instincts must be wrong. The closed packing (Orr) is neither mentioned nor discussed. The article by Sorrel and Mme. Sorrel-Dejerine on the various bone dystrophies is one of great interest, especially the section describing the painful epiphysitis of the spine in relation to Schmorl's observations about herniation of the discs. Nearly 100 pages are occupied by Cadenat and Fredet in describing the operative technique of osteotomy and osteosynthesis. The numerous and clear diagrams which accompany these articles make them of great value. In this country, where the operative treatment of fractures has so largely fallen into desuetude, it is well to have this clear exposition of the methods and possibilities of open fixation of bones, although we confidently believe that much of it will only be of historic value.

Bertrand's discussion of arthrodesis is too short to be of great value, but no doubt further details will be given in discussing the surgery of individual joints.

Diseases of the Testicle. By HAMILTON BAILEY, F.R.C.S., Surgeon, Northern Hospital; Surgeon and Urologist, Essex County Council; etc. Medium 8vo. Pp. 160 + viii, with 129 illustrations, of which 10 are coloured. 1936. London: H. K. Lewis & Co. Ltd. 12s. 6d. net.

THIS is one of the best monographs we have ever read; it contains a large amount of information which is treated with excellent judgement and set out with the author's usual lucidity.

Like the late Sir John Bland-Sutton, Mr. Hamilton Bailey is not afraid to enliven his text with anecdotes and with examples culled from the animal kingdom; is it possible that

the mantle of our one and only Sir John has fallen on this surgeon? Certain it is that his books are uncommonly readable.

To give a few examples: he recalls that Sir Astley Cooper taught that a man with bilateral maldescended testes was sterile, whereupon one of his pupils, a cryptorchid, left the room and committed suicide. At the necropsy which followed live spermatozoa were demonstrated. In his article on eunuchs he mentions the curious choir at St. Peter's, Rome, and quotes, "La voix des castrates imite celle des cherubims au ciel"; we have never thought of the bright-eyed cherubim as being sexually incomplete, but this seems entirely probable, for, like Peter Pan, they never grew up.

His account of the anatomy and physiology of the testicle and of the various incidents connected with its migration to the scrotum is the best we have met; the same may be said of his sections on rejuvenation, on neoplasms, and on the new method of early recognition of the latter.

It is because we have derived so much enjoyment from reading this little book that we venture on a few criticisms; they may be of help to the author when, as will assuredly happen, a new edition is called for in the near future.

In his remarks on torsion of the testis, or perhaps we should say of the spermatic cord, he calls attention to two points: the first, that such twisting never occurs except in a voluminous tunica vaginalis and with the testicle suspended therein by a definite pedicle: the second, that this accident is apt to happen on both sides, though never simultaneously. He infers, quite correctly, that after a patient has lost one testis as the result of torsion, it is good surgery to explore the other side of the scrotum and take measures to prevent the recurrence of such a disaster. The operation he describes for this purpose seems to us unnecessarily complicated; surely, if his theory of its causation is correct, all that is needed is to cut away the parietal tunica vaginalis or to do an eversion after the method of Jaboulay; either procedure will cure the condition, as we have found, indeed, in our own experience.

The illustration showing the lymphatics of the testis (*Fig.* 42) seems to be an unfortunate choice, for it shows the left kidney at a lower level than the right; we think that the author should insert a footnote to prevent the earnest student assuming that this is their normal relation.

There are a few instances of hurried writing or of the absence of a dictionary on the author's desk; such are the word 'constituency', which is more at home in politics than in describing the substance of a teratoma; also the new word 'absorpative'; in the account of Jaboulay's operation, the word 'eversion' is spelt correctly on one line and appears as 'evertion' on the next line. Orchiopexy rather jars on the nerves of the average reader, though we are assured that Torek states that it is etymologically correct.

These are, of course, minor faults, and the fact remains that this monograph is delightfully produced, beautifully illustrated, and would make quite an ideal companion on a long train journey. We warmly commend it to our readers, and we consider that it is a credit to British surgery and will be read with gratitude by every surgeon.

Estudos Cirurgicos. By Dr. EURICO BRANCO RIBEIRO, Surgeon to the Beneficencia Portuguesa and the Sanatorio Santa Catharina. 9¼ × 6¼ in. Pp. 245, with numerous illustrations. 1936. São Paulo, Brazil: Sociedade Editora Medica.

THIS book is a record of the industry and enthusiasm of its author, who is surgeon to the Sanatorio Santa Catharina in Sao Paulo. It is further evidence of what is now so well known, that surgery the world over is one, and that Portuguese-speaking people of South America enjoy medical service of the same order as that available in Europe.

It cannot perhaps be said that this volume offers much that is new to surgeons of other clinics and other climes, but the papers are so well documented that readers cannot fail to be repaid. The subjects covered range from the surgery of peripheral nerves in leprosy (removal of granulomatous masses without destruction of the trunks, and sometimes local resection) to the conservative surgery of the ovary; from the treatment of tetanus to that of post-operative ileus, for which Dr. Ribeiro recommends an extract derived from the chrysanthemum (*tanacetum*). Three papers deal with annular hypertrophy of the pyloric musculature in the adult; others with pancreatitis, osteomyelitis of the atlas, the use of sera in appendicitis, subpectoral abscess, fissured fracture of the lower end of the femur, and cancer of the gall-bladder. The range of the author's interests, the precision of his clinical observations, the broad-minded discussion of differing views, and his wide reading are reflected in his pages.

Allgemeine Chirurgie. By Prof. Dr. D. KULENKAMPFF, Chief of the Surgical Section of the Heinrich-Braun Hospital, Zwickau. Seventh revised edition. Large post 8vo. Pp. 246 + x, with 15 illustrations. 1937. Leipzig: J. A. Barth. RM. 7.50.

THIS book is so small and unpretentious that it is difficult to assess its value. It represents a very elementary introduction to surgical principles which might be read or referred to by those only wishing to acquire a superficial knowledge of surgery. A curious introductory chapter on the change in medical thought gives promise of a philosophical treatise. But the rest of the book is a short simple description of asepsis, anæsthesia, wounds, infection, certain specific infective diseases, injuries, and tumours.

We presume from the fact that this is the seventh edition, that the book must have fulfilled a certain function in German surgical teaching.

Verzögerte Knochenbruchheilung und Pseudarthrosenbildung, ihre Ursachen und Behandlung. By Prof. Dr. GEORG BRANDT, Director of the Surgical Clinic, Municipal Hospital, Mainz. 10¼ × 6¾ in. Pp. 175, with 223 illustrations. 1937. Leipzig: Georg Thieme. RM. 13.50; bound, RM. 14.80.

THIS excellent monograph consists of a study of the causes and treatment of non-union in fractures. In the earlier chapters the physiological and mechanical factors concerned in the repair of bone are discussed from the standpoint of the practical surgeon; this serves as a useful introduction to a consideration of the clinical types of non-union in the individual bones of the skeleton.

The author has had first-hand experience of the conventional methods of treating non-union in a personal series of 147 cases. He states frankly that he has nothing to offer as a solution of this problem, but he gives a concise and judicious survey of the methods likely to achieve success. There is an ample bibliography drawn from the literature of many countries.

Die Hirnkammerformen bei Hirntumoren. By Dr. OTTO DYES, Dozent für Röntgenheilkunde, Würzburg. Vol. 52 of *Fortschritte auf dem Gebiete der Röntgenstrahlen.* 12 × 8½ in. Pp. 79, with 105 illustrations. 1937. Leipzig: Georg Thieme. RM. 16; bound, RM. 18.

THIS monograph is devoted to the study of ventriculography and its value in the diagnosis and localization of brain tumours. After a very extensive trial both of the use of air ventriculography and of lipiodol injection into the ventricular system, Dr. Otto Dyes has been able to show quite definitely that this method of investigation has proved its worth inasmuch as in many cases it has given the precise position of a tumour where localization by clinical methods had been quite impossible.

The great feature of this monograph is the excellence of its skiagrams, showing every variety of filling defect of the various parts of the ventricular system of the brain. Tumours of the lateral ventricle give quite a characteristic filling defect, and localization is practically perfect after ventriculography.

English neuro-surgeons are probably a little more conservative than their confrères on the Continent, but this book should go a long way to stimulate them to use a procedure which is now almost devoid of risk in the hands of the expert. The great advantage of Dr. Otto Dyes's monograph is that a vast amount of clinical material has been analysed from the clinical, radiographical, and operative standpoint, which means that it will form a book of ready reference to those interested in neuro-surgery.

Scalpel and Sword. By SIR JAMES ELLIOTT. Demy 8vo. Pp. 215 + viii. 1937. London and Sydney: Angus & Robertson Ltd. 7s. 6d.

IN this book of reminiscences, the author, a well-known consulting surgeon in Sydney, has written over 200 pages of interesting, not to say thrilling, stories of his eventful life. He gives a most vivid account of his preliminary studies in the University of Otago, his journey to Edinburgh, his life in its Medical School (where he qualified), and of the famous masters and teachers of that day. In contrast he relates his experiences in the Boer War, and later, the Great War. The accounts of his visits to Surgical Clinics in the United States are particularly interesting.

In the last chapter, the author shows a delightful picture of the beauties of New Zealand, revealing his love of nature and his keen interest in botany.

Sir James Elliott has written this book in a particularly attractive manner and with such an easy grace that it is a pleasure to recommend it to our readers.

BOOK NOTICES

[The Editorial Committee acknowledge with thanks the receipt of the following volumes. A selection will be made from these for review, precedence being given to new books and to those having the greatest interest for our readers.]

Rose and Carless's Manual of Surgery for Students and Practitioners. By CECIL P. G. WAKELEY, D.Sc.Lond., F.R.C.S.Eng., F.R.S.Edin., Senior Surgeon, King's College Hospital, and JOHN B. HUNTER, *M.C.*, M.Chir.Cantab., F.R.C.S.Eng. Fifteenth edition, in 2 volumes. Large 8vo. Pp. 1617. Figs. 948, with 29 coloured plates. London: Baillière, Tindall & Cox. 30s. net.

A Manual of Operating Room Procedures. By ALMIRA W. HOPPE, Science Instructor, Jewish Hospital of St. Louis; and LUCILE M. HALVERSON, Supervisor of Operating Rooms, University of Minnesota Hospitals. 9¼ × 6 in. Pp. 239 + xii (including blank facing-pages in text), spiral wire binding. Minneapolis: The University of Minnesota Press. London: Humphrey Milford, Oxford University Press. 9s. net.

La Spondylolyse et ses Conséquences. By P. GLORIEUX, Bruges, and C. ROEDERER, Paris. 10⅝ × 7 in. Pp. 207 + vi, with 138 illustrations. 1937. Paris: Masson et Cie. Fr. 60.

Die Technik der Operation der Gaumenspalten und Gaumenlippenspalten nebst Ergebnissen. By Dr. K. LUHMANN, Oberarzt der Chirurg, Universitätsklinik Breslau. 9⅝ × 6⅝. Pp. 99 + vi, with 170 illustrations. 1937. Leipzig: J. A. Barth. RM. 9.60.

Wundheilung. By Prof. Dr. WILHELM LÖHR, Direktor der chirurgischen Klinik des städtischen Krankenhauses Magdeburg-Altstadt. Imperial 8vo. Pp. 234 + vi, with 141 illustrations. 1937. Leipzig: J. A. Barth. RM. 21; bound RM. 23.

Einführung in die Ventrikulographie. By Dr. BENNO SCHLESINGER. Large royal 8vo. Pp. 246 + xii, with 146 illustrations. 1937. Berlin and Vienna: Urban & Schwarzenberg. RM. 18; bound, RM. 20.

Die Drahtextension. Anleitung zum praktischen Gebrauch. By Prof. Dr. RUDOLF KLAPP and Dr. W. RÜCKERT. 9⅜ × 6¼ in. Pp. 146 + viii, with 185 illustrations, some in two colours. 1937. Stuttgart: Ferdinand Enke. RM. 14; bound, RM. 15.80.

The Lung. By WILLIAM SNOW MILLER, Emeritus Professor of Anatomy, University of Wisconsin. 9 × 6 in. Pp. 210 + xv, with 152 illustrations. 1937. London: Ballière, Tindall & Cox. 34s.

Surgical Pathology of the Thyroid Gland. By ARTHUR E. HERTZLER, M.D., Surgeon to the Agnes Hertzler Memorial Hospital, Halstead, Kansas; Professor of Surgery, University of Kansas. 9½ × 6½ in. Pp. 298 + xviii, with 238 illustrations. 1937. Philadelphia and London: J. B. Lippincott Co. 21s. net.

Source Book of Orthopædics. By EDGAR M. BICK, M.A., M.D., Adjunct Orthopædic Surgeon, Hospital for Joint Diseases and Mt. Sinai Hospital. 9 × 6 in. Pp. 376 + xv. 1937. Baltimore: The Williams & Wilkins Co. (London: Ballière, Tindall & Cox.) 15s.

Handbook of Orthopædic Surgery. By ALFRED RIVES SHANDS, jun., B.A., M.D., Associate Professor of Surgery in charge of Orthopædic Surgery, Duke University School of Medicine; in collaboration with RICHARD BEVERLY RANEY, B.A., M.D., Instructor in Orthopædic Surgery, Duke University School of Medicine. 9¾ × 6 in. Pp. 593, with 169 illustrations. 1937. London: Henry Kimpton. 21s. net.

Traité de Chirurgie orthopédique. Published under the direction of Professors L. OMBRÉDANNE and P. MATHIEU; Editorial Secretaries, M. LANGE, G. HUC, and P. PADOVANI. In 5 volumes. Large royal 8vo. Vol. II. Physiology, Pathology, and General Treatment (*contd.*); The Spine. Pp. 1016, with numerous illustrations. Vol. III. The Spine (*contd.*); The Upper Extremity. Pp. 952, with numerous illustrations. 1937. Paris: Masson et Cie. Fr. 270; bound, Fr. 300. The whole work, Fr. 1100; bound, Fr. 1250.

Medical Urology. By IRVIN S. KOLL, B.S., M.D., F.A.C.S., Attending Urologist, Michael Reese Hospital, Chicago, Ill. 9¼ × 6¼. Pp. 431, with 92 text illustrations and 6 coloured plates. 1937. London: Henry Kimpton. 21s. net.

Vorträge aus der praktischen Chirurgie. Edited by ERICH LEXER. Heft 13. Die Bluttransfusion und ihre Bedeutung für die Praxis. By Prof. Dr. TH. NAEGELI, Bonn. Large Royal 8vo. Pp. 26. 1937. Stuttgart: Ferdinand Enke. RM. 1.80.

Wesen, Erkennung und Behandlung der Krebskrankheit. By Geh.-Rat Prof. Dr. FRITZ KÖNIG, Würzburg, and Prof. Dr. ERNST SEIFERT, Würzburg. Bd. 57 of *Neue Deutsche Chirurgie* (Lexer). 10½ × 7⅛. Pp. 300 + viii, with 29 illustrations and 1 graph. 1937. Stuttgart: Ferdinand Enke. RM 25.70; bound, RM 27.70.

Infantile Paralysis and Cerebral Diplegia. Methods used for the Restoration of Function. By ELIZABETH KENNY. With a Foreward by HERBERT J. WILKINSON, Professor of Anatomy and Dean of the Faculty of Medicine, University of Queensland. Demy 8vo. Pp. 125 + xxxviii, with numerous plates. Sydney: Angus & Robertson Ltd. 21s.